Scuola Superiore Sant'Anna
di Studi Universitari e di Perfezionamento

The link between environment and competitiveness

An analysis of the relationship among regulatory pressures, environmental practices and competitive performance at the firm level

A thesis presented
by
Francesco Testa
to
The Class of Social Sciences
for the degree of
Doctor of Philosophy
in the subject of
Management, competitiveness and development

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CHAPTER 1: Introduction

1. Theoretical framework

In general, the effects of environmental regulation and market incentives on society can redistribute income streams and can have an impact on the standard of living. These effects are also often analyzed in relation to the concept of “competitiveness”. Literature and empirics on competitiveness focuses on price and cost developments of production factors and other parameters that can potentially affect economic growth, market shares and other performances of companies in the targeted sectors.

This following definition of competitiveness, provided by the European Commission (EC, 2004), helps to identify a first relevant impact of environmental policies on market performance: “their capability to raise costs for companies and sectors operating within an industry.”

Environmental policies and, especially, regulation can create costs for industries through three different channels:

- A limit to water consumption or to air emissions is able to affect the resource “productivity”, or to induce the search for substitutive inputs (such as other forms of energy for cooling the production plants) or alternative production technologies.
- A tax or levy, usually imposed on a production input (water or energy) or a service (waste or water treatment) directly increases variable costs (or the company chooses to sustain the costs of pollution abatement as a means to avoid the levy, i.e.: fix costs for the investment in technologies and the connected variable costs). Taxes on water or air emissions, in fact, have proved to effectively encourage increases in environmental expenditures by polluters. Symmetrically, incentives and subsidies can be applied as economic instruments for environmental policies, either from domestic sources or from the EU’s structural funds.

- The adoption of a “Best Available Technique” (e.g.: suggested by a dedicated Bref document) may entail additional costs, depending on the nature of the policy measure, e.g.: companies in a sector may have to invest in “end-of-pipe” equipment, and switch resources from production to monitoring and/or reporting of emissions, for example. On the one hand, they will face costs if the measure requires process-oriented investment that makes existing equipment obsolete before the end of its useful life, because the newly required technology cannot be added onto the existing equipment. On the other hand, modern technology can also avoid cost, especially in the use phase (less energy for heating and cooling).

From a cost perspective, an increase in the fixed or variable costs of a production input is likely to lead to a deterioration of the competitive performance. More specifically in those cases where environmental policy reduces the possibility to use a particular input, decreases productivity and/or increases the price of the output. Economic literature emphasizes that the above costs will have effects on profitability, prices, demand dynamics, innovation and productivity and investment decisions of the affected industries.

A first interpretation for these effects is provided by the so-called “structuralist” approach. This approach focuses mostly on the effects on the market forces caused by the characteristics of the sector “structure” of costs and of the market. This approach is also known in literature as the “structure-behaviour-performance” approach.

According to this approach, the extent and the negative/positive outcome of these environmental policies effects depend to a large extent on (i) how the affected companies (industries) finance abatement technologies (additional borrowing on capital markets, price increases, cuts in dividends, cost savings, cuts in other expenditures such as R&D budgets, …), and (ii) market structures (price elasticity of demand, degree of exposure to international competition, …) (Gollop and Robert, 1983; Letchumanan and Kodama, 2000).

Such environmental policies may have long-term effects on productivity even if they reduce the resources devoted to “traditional” research and innovation: if a company diverts resources from research and innovation to environmental expenditure, then the

immediate impact on the costs is zero, but the lower level of spending on research and innovation will have adverse impacts on the company over time.
The "structuralist" approach identifies two kinds of final consequences on market dynamics:

- A worsened performance of an industry, due to the implementation of an environmental policy or regulation, measured by its growth parameters (sales, turnover, ecc.);
- A significant change in the structure of the industry (companies shutting down or moving to the so-called "pollution heavens") or in the market structure (market shares shifting to industries operating in other contexts - e.g.: competitor sectors, countries or regions).

A second interpretation of the impacts of environmental regulation on market forces and competitiveness can be referred to the so-called "Porter hypothesis". According to Porter (Porter & van der Linde, 1995a), the effects of environmental policies could be rather different from what is often supposed; in particular, any loss of competitiveness will be short-lived in terms of lost output, with a longer term boost to output due to enhanced productivity effects. The competitiveness of an industry is essentially based on the capabilities of its companies to exploit and optimize the resources available. Environmental regulation, therefore, can bring to a better and most effective use of the resource and improve its "productivity". The effects of environmental policies on market forces are therefore measured in a dynamic way, relying on parameters such as "resource productivity" (e.g.: valued added per unit of final output, average unitary cost, ecc.) or innovation capabilities (e.g.: investments in R&D, ecc.). Moreover, by optimizing the use of a scarce resource such as energy or water, an industry can make it more available in the future, guaranteeing a higher sustainability to its production and, therefore, its business continuity.

A third and more recent interpretation on the impacts of environmental policies on market dynamics is proposed by the so-called "Resource-Based View". According to this approach, competitiveness and success of companies and products depend on the quality and quantity of the resources available and by the ability of companies/industries to optimize their use (Fouts and Russo, 1997). This approach is an evolution of the Porter's approach, as it enlarges the typologies of resources that the companies and industries can rely on.

The Resource-Based View identifies five kinds of resources (Grant, 1991):

- Financial and economic resources (as in the "structuralist approach");
- Physical resources (as in the Porter's model);
- Human resources (and their competence / know-how);
- Technical (considering innovation capabilities);
- Intangibles (e.g.: reputational, managerial, organizational,…).

This approach emphasizes that, while the first kind of resources (financial and economic) can be influenced negatively by the effects of environmental regulation described above, at least in the short run, all the other kinds can benefit from their application, especially if we consider them in dynamic terms. For example:

- a policy can improve the capability of an industry to use a lower quantity of physical resource per unit of product (i.e.: increase productivity) or, by way of water saving techniques or substitution with other inputs, can guarantee a higher availability of the resource in the future or even prevent a rise in costs due to future scarcity.
- as concerns human resources, there are non-monetary economic impacts reducing the pollution negative effects on health and, therefore, tending over time to lead to a workforce that is more productive (because it is healthier).
- even more significant can be the positive effects on technical resources of a regulation, by stimulating new technology development and improving the innovation capacities of the companies and of the whole industry. Taxes, clean technologies and even well-designed regulatory instruments (i.e.: limits) generally encourage companies to seek innovative solutions that otherwise would remain unexplored.

Intangibles assets can also be improved by an environmental policy, insofar as it stimulates the adoption of good practices by the industry, that are able to provide immaterial and sometimes even non-monetary benefits (such as a better reputation and image on the market, a higher level of compliance with legislation, etc.).

2. Definitions and measurements of competitiveness

The variety of perspectives and levels of analysis at which the concept of competitiveness may be considered complicates the formulation of an univocal definition of competitiveness both at a theoretical and political level.

This is corroborated by the analysis of the main definitions of competitiveness - provided by the most important institutions at the European and the international level - where the authors have found a number of different perspectives on competitiveness and significant differences in the emphasis of certain elements of competitiveness.

The definition provided by the European Commission in its annual Competitiveness Report (European Commission, 2008) mainly aims at proposing an analytical framework to assess the impact of policies – including environmental policies – on competitiveness. This definition stresses the importance of the so called "domestic factors" as dominant determinants of competitiveness. The definition of OECD of a nation's competitiveness emphasizes the ability of a country to produce goods and services which meet the test of international markets, while simultaneously maintaining and expanding the real incomes of its people over the long term[1] (OECD, 2003). A third "institutional" definition of competitiveness has been provided by the World Economic Forum. The World Economic Forum considers the level of productivity of a country as a key element to determine the competitiveness of a nation. It defines the competitiveness as "*the collection of factors, policies and institutions which determine the level of productivity of a country and that determine the level of prosperity that can be attained by an economy*" (World Economic Forum – Global Competitiveness Report, 2007)

By analyzing the different definitions of competitiveness provided by scholars, institutions and practitioners, it is possible to set a common "ground": competitiveness is generally defined as "*The ability of an 'entity' – a country, a region, an industry, a firm – to produce products or services of a superior quality and/or at lower costs than other entities that act in the same economic context (i.e. a competition "arena", such as a market or a sector)*". The ability of an "entity" to prevail on its competitors is

[1] An OECD paper (2003) states that "*Competitiveness is primarily a matter of being able to produce goods that are either cheaper or better than those produced by other firms*".

determined and/or influenced by the capacity to use its own resource's endowment more efficient and effective in order to obtain a better performance.

Starting from this "common ground", a deep understanding of the concept of competitiveness needs to provide answers to three major questions:

1. *Who is the entity that competes with others?*
2. *What is the "context" in which this entity competes with its competitors?*
3. *What are the drivers and factors that enable this entity to perform better than its competitors?*

2.1 Competitiveness from entities' perspective

The first question refers to the "entities" that are the relevant actors in the competition "arena". Literature distinguishes three basic typologies of actors: i) *a single firm* or *plant*, ii) *a cluster of firms*, i.e. an industry, a sector, a branch or a local productive system (e.g. an industrial district), and iii) *a territorial context* (i.e. a country or a region).

At the firm level, competitiveness implies that companies are able to produce goods and services more efficiently and/or effectively than their competitors. A strong competitive performance is achieved by relying on some "competitive factors", often with a particular focus on process productivity and the efficient use and/or access to strategic inputs. Jenkins (1998) states that, "*a firm is competitive if it can produce products or services of a superior quality or at lower costs than its domestic and international competitors. It is therefore synonymous of a firm's long-run profit performance and its ability to compensate its employees and provide superior returns to its owners*". A recent paper for the International Energy Agency defines competitiveness at the firm level as "*the ability to maintain and/or to expand [a] market position based on its cost structure*" (Reinaud, 2005).

At the sectoral level, competitiveness implies that competitive factors are activated and used by different "clusters" of companies (e.g. all the companies operating in similar industrial sectors in different countries) to realize a better performance in the relevant market (local and/or international markets). In this case, the competitive performance is measured by aggregating the performance of the single firms operating in the same cluster. This level is related to the previous one, but not totally overlapping: in fact, a competitive industry can be composed by a high number of competitive firms, but also by some low-performing firms.

At the territorial level (country or region), the concept of competitiveness is not limited to a market perspective, but is also related to the "standard of living" within a certain geographical area. This relation makes that competitiveness as such cannot be considered a zero-sum game, as one country's or region's gain does not necessarily come at the expense of the other. Moreover, competitiveness of a country or region is the result of a wide range of drivers and performances at the regional, sector, firm and plant levels, and the interactions thereof with a number of institutional and social factors. It is therefore that competitiveness at the territorial level cannot be considered as the mere "sum" of the previous levels (i.e. firm/plant and sector level).

2.2 Dimensions of competitiveness

The second question refers to the "dimension" of competitiveness. At least three dimensions: international, national and local competitiveness can be distinguished.

At the international level, competitiveness refers to the success with which an entity (i.e. a country/region, a sector/industry, a firm/plant) competes against overseas counterparts. The most important and widely-used definition of international competitiveness are those provided by the OECD and the EC:

- "*The degree to which (a country) under free and fair market conditions, produce goods and services which meet the tests of international markets, while simultaneously maintaining and expanding the real incomes of its people over the longer term*" (OECD, 2003);
- "*Competitiveness is understood to mean high and rising standards of living of a nation with the lowest possible level of involuntary unemployment, on a sustainable basis*" (European Commission, 2008).

At the national level, literature focuses on the measures of competitiveness, such as *levels* and *growth* of *Gross Domestic Product* or *Gross National Product* (SQW, 2006), *GDP per capita* (Esty *et al.*, 1991) and *international trade flows* (Florax *et al.*, 2001). In the view of most authors, the fundaments of national competitiveness rest on the efficiency with which resources are allocated and used at micro level (i.e. at sectoral and/or firm level).

Finally, the assumption of the local competitiveness perspective implies the consideration of a series of factors related to the characteristics of a territory/region, going beyond the behavior of local economic actors. Most of all, there are two factors based on theories that point out the relevance and impact of the link between territorial localization and competitiveness, which appears to be crucial. The first is that economic, entrepreneurial and technological activities tend to agglomerate at certain places, leading to patterns of regional and local specialization. The second is that the competitive performance and development of a firm seems to be determined - to a considerable extent - by the conditions that prevail in its environment, and that the conditions in the immediate proximity – in the local *milieu* - seem to be particularly important (Iraldo, 2002; Dicken and Lloyd, 1997; O'Sullivan, 1984) for competitive performance.

2.3 Key variables of competitiveness

The third question refers to the analysis of the *key variables* affecting competitiveness as well as the *ways to measure them*. As mentioned above, the variety of definitions of competitiveness provided by scholars and institutions according to the different possible levels of analysis runs parallel to the existence of many approaches and indicators aimed at measuring competitiveness. In an attempt to structure existing approaches, two major approaches may be distinguished:

- The first one tries to investigate the *drivers of the competitiveness* (e.g. the resource productivity at firm level, the degree of internationalization at sector level).
- The second approach focuses on the *external effects of the competitive success* (e.g. the market performance measured by market share; the turnover growth rate; the financial performance measured by ROI or EBTIDA at firm level; the welfare of a nation measured by GDP *per capita*).

According to our framework of analysis, competitiveness can be measured at: the *macro level* (territorial: international/national); the *meso level* (cluster: sectoral/industry/district) and the *micro level* (plant/firm).

a) At the macro level, measurements of competitiveness aim at describing how successfully a country or a region (made up of different sectors and many firms) competes with counterparts in other countries. As mentioned above, the most common indicators to compare competitiveness between countries are *Gross Domestic Product* (GDP) and *Gross National Product* (GNP) (SQW, 2006), *GDP per capita* (Esty *et al*., 2001) and *international trade flows* (Florax *et al.*, 2001). The first three indicators focus on the effect of competitiveness on the "standard of living" of citizens, while the fourth indicator is similar to those used for sectors and industries as it basically underlines the ability of a country to tackle the international competition. Indicators aimed at measuring competitiveness at this level rely on the fact that a country can be gauged competitive compared to other countries if it consistently exports goods earlier than others do (Depperu, 2006; Rose, 1997; Feenstra and Rose, 1997).

b) Measurements of competitiveness at the industry level especially refer to the ability of specific industries to compete for market shares with businesses operating in the same sector but located in other countries or regions. Most studies use *trade* (e.g. net exports), *investment flows* and *market shares* as proxies or indicators of sectoral competitiveness (OECD, 2003). Other studies seek to consider the drivers of trade competitiveness at the sectoral level, such as the *Total Factor Productivity* and/or proxy measures of *innovative capacity* (mainly R&D expenditure and patent applications) (Jaffe and Palmer, 1997). The different localization usually affects the availability of production factors and inputs, including natural resources (Peterson, 2003). Some authors (Iraldo, 2002; Cainelli & Zoboli 2004) focus on the competitive advantage obtained by firms operating in a *local system* of production (as an industrial district or regional cluster). Finally, financial measurements such as *operating profit* and *Earnings Before Interest, Tax, Depreciation and Amortisation* (EBITDA), even if rarely, are also used in the literature as a measure of sectoral competitiveness (Carbon Trust, 2004).

c) At the *level of firms/plants*, competitiveness indicators relate to various aspects, such as the ability to sustain market shares, to sustain independent existence on the market or to sustain "normal" levels of profitability and returns. At the firm level, *productivity* is the key variable, simply defined as the "*measure of output per unit of input*". Productivity aims at measuring the efficiency with which production is carried out; in other words, the ratio between the outputs and inputs that make production possible (raw materials, labour, capital etc). Many studies identify as an optimal measure of productivity the *Total Factor Productivity*, that is a synthetic measure of how firms are organized, structured, use technology and are managed (for instance see: Jaffe and Palmer, 1997; Dofour, Lanoie and Patry, 1998; Berman and Bui, 2001).

In conclusion, table 1 provides a summary of the overall framework that is established for analyzing competitiveness as well as on and the different ways to measure it.

Table 1 Measurement and indicators of Competitiveness – Summary table

Level of Analysis		**Measure of Competitiveness (Driver *vs* Performance)**	**Indicator**	**References**
MACRO	**International / National**	**Prosperity/Standard of living** *(Performance)*	*Growth rate of real GNP*	Jorgenson and Wilcoxen (1990)
			Level and growth of GDP and GNP	Jorgenson (1991)
			GDP per capita; GDP per capita adjusted for purchasing power	World Economic Forum (2007) Esty et. al. (2001)
		International Trade *(Performance)*	*Net Export*	Depperu (2006) Mulatu et al.(2004) Rose (1997) Feenstra and Rose (1997)
			International trade flows	Mulatu *et al.* (2001)
		Productivity (*Driver*)	*Productivity growth*	Jaffe *et al.* (1995)
MESO	**Sector / Industry**	**Market Performance** *(Performance)*	*Market share*	Peterson (2003)
		Financial Performance *(Performance)*	*Earnings Before Interest, Tax, Depreciation and Amortisation (EBITDA)*	Carbon Trust Paper (2004)
		International Trade *(Performance)*	*Net Export*	OECD (2003)
		Investment *(Driver)*	*Investment flows*	OECD (2003) Leonard (1984;1988)
			Direct foreign investment	Blazejcack (1993)
		Productivity *(Driver)*	*Total Factor Productivity (TFP)*	Jaffe and Palmer (1996) Lanoie, Patry, Lajeunesse (2001)
		Innovation *(Driver)*	*R&D expenditure and Patent applications*	Jaffe and Palmer (1997)

		Resource endowment *(Driver)*	*Localisation*	Peterson (2003) Cainelli & Zoboli (2004)
			Cost of transport	O'Sullivan (1984)
			Proximity	Iraldo (2002) Dicken and Lloyd (1997) Krugman and Obstfeld (1995)
MICRO	**Firm / Plant**	**Market Performance** *(Performance)*	*Turnovers*	Dofour *et al.* (2007) Levy (1995)
			Market growth	Gray and Shadbegian (1993)
			Market share	Gray and Shadbegian (1993)
			Import or Export Performance (e.g. net exports)	Cagatay, Koska and Mihci (2004)
			Firm's or plant's survival over time on the market	Levinson (1995)
		Economic Performance *(Performance)*	*Return on Equity (ROE) and Return on Assets (ROA)*	Bragdon and Marlin (1972) Fouts and Russo (1994)
			Return on Sales	Levy (1995)
			Net Income	Freedman and Jaggi (1992) Brannlund *et al.* (1995)
		Financial Performance *(Performance)*	*Cash Flow (Equity and Assets)*	Freedman and Jaggi (1992)
			Return on Investment (ROI)	SQW (2006)
		Efficiency *(Performance)*	*Estimated Cost Function*	Gollop and Roberts (1983) Sims and Smith (1983)
			Ability to distribute costs of compliance	Helland and Matsuno (2003)
		Innovation *(Driver)*	*R&D Expenditure*	Jaffe and Palmer (1997)
			Patent Applications	Brunnermeier and Cohen (2003) Landjouw and Mody (1996) Popp (2003)
		Productivity	*Output*	SQW (2006)

	(Driver)	*Estimated Profit Function*	Alpay *et al.* (2002)
		Total Factor Productivity (TFP)	Berman and Bui (2001)
		Labour Productivity	SQW (2006)
		Plant location or locational decisions	Levinson (1995)
	Resource endowment *(Driver)*	*Localisation*	Peterson (2003) Cainelli & Zoboli (2004)
		Cost of transport	O'Sullivan (1984)
		Proximity	Iraldo (2002) Dicken and Lloyd (1997) Krugman and Obstfeld (1995)

3. Environmental policy instruments: a classification according to their potential effects on competitiveness

Economic theories differ in their consideration of environmental policy instruments. For instance, *neoclassical models* assume that different technological options are available to all actors and actors constantly optimize costs and benefits. Alternatively, *Institutional models* assume that technological options are not necessarily available to all actors, due to the uncertainty of the innovation process and to the fact that actor behavior is characterized by bounded rationality (Berkhout, 2001).

Environmental policy instruments are usually classified into three categories depending on the degree of strictness: *direct regulation* (*command and control*), *economic instruments* and *soft instruments*.

In the following paragraphs, a summary of the main features of these categories as well as their potential effects on competitiveness is presented.

3.1 Direct regulation

Direct regulation includes *standards* as well as *commands and prohibitions* and can be classified into: input regulation, process regulation, and output regulation. Neoclassical theory suggests that command and control measures cause the highest cost of environmental policy instruments, since it is difficult for this set of instruments to differentiate between the different polluters. All regulated subjects are treated similar despite individual differences in abatement cost.

Focusing on their potential effect on competitiveness, empirical studies show contradicting evidence regarding innovation effects. Hemmelskamp (1999) emphasizes that the polluter has no incentive to lower its emissions beneath the regulated standards, as pollution lower than the standard does not incur any cost. Kuntze (1999) suggests that the potential of regulation to stimulate innovation effectively depends on its specific design regarding its requirements (e.g. standards or best available technology), inclusion of dynamic aspects, coverage (e.g. exceptions, inclusion of old plants, etc.), and implementation (flexibility, enforcement, etc.). Some studies emphasize that regulation merely enforced the diffusion of existing technology, while others claim that regulation also stimulates innovation, provided they are stringent and focused, and follow the idea of technology forcing (Kemp, 1997; Ashford, 2000). In other words, stringent standards seem to be a prerequisite for competitive advantages through innovation. Regulation mandating the use of best available technologies helps industry to increase efficiency, especially if implementation is supported by senior officials but do not alter substantially technology (Gouldson and Murphy, 2000). This finding draws attention to the fact that also process innovation or the application of existing technologies might lead to cost savings within firms.

3.2 Economic instruments

Market-based instruments include duties and tradable emission permits as well as environmental liability (Kuik and Osterhuis, 2008). Environmental duties can take the form of taxes, charges, dues, or extra duties. Their function is either to increase state income, to give an incentive to the change of the behavior of the regulated subject, or to support the implementation of another environmental regulation. The instrument of tradable emission right requires the regulating body to define a total number of emission permits representing the desired total volume of emissions. Each permit guarantees the right for a fixed amount of emission within a certain time frame.

For some authors market based instruments are likely to have significantly greater, positive impacts over time than command-and-control approaches on the invention, innovation and diffusion of desirable, environmentally-friendly technologies (Jaffe *et* *al.*, 2002) Economic theory suggests that market-based instruments are the first best choice when internalizing external environmental effects, as they lead to cost efficiency (Requate and Unold, 2003). Their assumed status as first best choice gains further support through empirical studies showing that innovation decisions are affected by price effects / changes in relative prices of production factors.

There is considerable debate within economic literature about which of the individual economic instruments is more likely to spur innovation. Milliman and Prince (1989) find that auctioned emission permits show the highest level of innovation incentives followed by an emissions tax and then grandfathered emissions, while Fisher *et al.*(2003) dispute this ranking.

3.3 Soft instruments

Soft instruments include *voluntary industry agreements, communication* and *information measures* as well as *environmental management schemes (EMS)*. Voluntary agreements are rarely considered in research regarding competitiveness. Brockmann (1999) states that they support the diffusion of existing technologies if their application is economically feasible for the industry. Information and communication tools like labels do not induce innovative activity on the firm side although they potentially increase competitiveness in certain market segments (Jacob and Rennings, 2007).

EMS encourage organizational change with a direct impact of the environmental performance of the firm. Moreover, empirical investigations based on industry surveys find a positive correlation between the implementation of EMS and process as well as product innovation (Arimura *et al.* 2007).

4. Aim, scope and outline of this thesis

The above sections summarize the main findings emerging from the literature on the link between environmental policies, environmental and competitiveness performance. They highlight that the available empirical evidence does not allow to state that any strand of research has succeeded over the others, as no unique relationship has prevailed in literature or empirical studies so far. For this observation, a number of explanations have been brought forward. These include *methodological reasons*, such as the lack of statistical data or its low quality or the fact that environmental data is often available for short time periods only. Furthermore, various *theoretical explanations* are developed, such as the influence of different corporate strategies or a relatively small influence of environmental issues in industry on the economic success of firms.

Overall, the relationship among environmental policies, environmental performance and competitiveness may vary depending on *the source* of the regulation, *its form* and *the environmental assets* it is seeking to protect. The *methods of assessing* the relationship may also generate different estimates of the direction and strength of the effect of regulation on competitiveness. For instance, longitudinal or time series studies can capture the passage of time and the dynamic adjustment process to an extent that cross-sectional studies - even at different points in time - would find more difficult.

Two variables in particular have proved to be both (i) key in defining to what extent and under what conditions environmental regulation exerts adverse or positive effects on competitiveness and (ii) difficult to nail down: *forms of regulation* and *responses by business*. The form of regulation may be as important as its stringency in determining the nature of its relationship with competitiveness; though, there is little from the literature that helps define or capture the form of regulation. Especially in terms of how regulation allows flexibility for business responses at the same time as it achieves its environmental objectives. Still, recent studies support the idea and provide evidence that the key question is not "*which instrument is best*", but "*which mix of instruments is best*". This implies that using market-based instruments alongside other environmental measures such as regulations is optimal both in terms of using the preferred mix of instruments to meet environmental objectives as well as in combination with other (e.g. economic and social) objectives. The relationship between environmental policies, environmental performance and competitiveness may also vary depending on the characteristics of the businesses and sectors concerned (e.g. market power may apply only to some businesses as the ability to pass on any increased costs from regulation to the consumer). Moreover the single firms, stimulated by external pressures (e.g. increased environmental awareness of consumers, suppliers, local community, institutions) can implement effective actions able to improve their environmental performance as well as to achieve a competitive benefit.

Based on these considerations, the main question for this dissertation is:

> *How can the environmental regulation and practices be effective, or improve the environmental performance of the firms, and provide competitive advantages to the targeted firms or adopters?*

Several research question have been derived from this:

I) Is a stringent environmental regulation able to positively affect the competitive performance of firms?

II) What are the main differences between the forms of environmental regulation in the relation between environmental regulation, environmental performance and competitiveness?

III) Are the flexible forms of environmental regulation, such as voluntary instruments on environmental management systems, able to influence the environmental and competitive performance?

IV) Which are the effects of environmental practices based on the cooperation between the supply chain actors?

In this dissertation, in order to answer the above mentioned questions, we applied regression analysis to different datasets, focused on several sectors. This choice is justified by the fact that we tried to overcome the typical limit of studies case study-based. These studies, in fact, provided very useful evidence and indications to practitioners but do not provide sufficient proofs to generalize their findings and, therefore, to understand if a specific environmental regulation or a managerial tool is really able to guarantee environmental and competitive improvements.

Chapter 2 of this thesis explores *reseach questions I* and *II* focusing on a specific industrial sector: the buildings and construction (B&C) sector. This sector is a substantial contributor to most countries' Gross Domestic Product and its final product, in a life cycle perspective, makes up 20 to 35% of the impacts of all products for main environmental impact categories such as global warming, abiotic depletion, human toxicity, ozone layer depletion (Tukker *et al.* 2006). Using qualitative data collected within the recently-completed EMPIRE project , we assess the effect of stringency and forms of environmental policies on competitive performance of firms of the building and construction sector.

Chapter 3 of this thesis focuses on the *reseach questions III* and investigates the role of a specific environmental policy instruments designed by European Commission in the '90ies. This is the EMAS Regulation (Reg 761/01 EC), an EU scheme implemented by the European Commission since 1993 for the implementation of an Environmental Management System (EMS) by any organization. Using qualitative data collected by a standard questionnaire, the Chapter 3 investigates whether or not an EMS implemented within the EMAS Regulation has any effect on firm performance both from an environmental and a competitive point of view.

Research question IV is analyzed in *Chapter 4*. Drawing upon a database of over 4,000 manufacturing facilities in seven OECD countries this chapter assesses the determinants and motivations for the implementation of Green Supply-Chain Management (GSCM) as well as its effect on environmental and commercial performance.

Finally, the *Chapter 5* presents a summary of the chapters and the main conclusions of this thesis.

CHAPTER 2: The effect of environmental regulation on firms' competitive performance: the case of building & construction sector in European regions

Abstract

There is a considerable debate about the effect of environmental regulation on competitive performance. Based on survey data this chapter tests the two main hypotheses deriving from the literature on links between environmental regulation and competitive performance, focusing on firms of the building and construction sector: i) How does the environmental policy stringency affect the competitive performance of firms in the building and construction sector? ii) How does the form of environmental regulation affect the competitive performance of firms in the building and construction sector? Applying a regression analysis, I find that a more stringent environmental regulation provides a positive impulse for increasing investments in advanced technological equipments and innovative products; moreover, the well-designed direct regulation is actually the more effective policy instrument regarding the positive impact on competitiveness.

1. Introduction

There is a considerable debate about the most effective and efficient regulatory mechanisms to improve the environmental and competitive performance of industry. In general, the effects of environmental regulation on society can redistribute income streams and can have an impact on the standard of living. These effects are also often analyzed in relation to the concept of "competitiveness". Literature and empirics on competitiveness focus on price and cost developments of production factors and other parameters that can potentially affect economic growth, market shares and other performances of companies in the targeted sectors.

From a cost perspective, neoclassical economic theory suggests that direct regulation imposes private costs on polluters to reduce social external costs (Gray and Shadbegian, 2003). It emphasizes that the additional costs have effects on profitability, prices, demand dynamics, innovation and productivity and investment decisions of the affected industries. A typical case is the buildings and construction (B&C) sector, which often is a substantial contributor to most countries' Gross Domestic Product, as it has a significant share within other economic indicators, such as national added value and employment. Moreover, its final product, in a life cycle perspective, makes up 20 to 35% of the impacts of all products for main environmental impact categories such as global warming, abiotic depletion, human toxicity, ozone layer depletion (Tukker *et al.* 2006). This sector, furthermore, has often been considered under threat by losing its competitiveness as a result of extensive energy and environmental regulations and policies addressing construction and construction-related activities

On the contrary, the theory of dynamic competitiveness deriving from technological innovation linked to stringent environmental standards has been exposed by Porter and van der Linde (1995b). They suggest that, by driving innovation and resource-use efficiency, environmental regulation can actually improve competitiveness and offset compliance costs.

In this paper we test the two main hypotheses deriving from the literature on links between environmental regulation and competitive performance, focusing on firms of the building and construction sector: i) How does the environmental policy stringency affect the competitive performance of firms in the building and construction sector? ii)

How does the form of environmental regulation affect the competitive performance of firms in the building and construction sector?

In order to perform the empirical investigation I used qualitative data collected within the recently-completed EMPIRE project, funded by SKEP ERA-NET (Scientific Knowledge for Environmental Protection), which examined the interplay between environmental regulation and market forces with respect to the building and construction industry.. The EMPIRE project, coordinated by the Center for the Development of Product Sustainability (CESISP) in Genoa (Italy), has carried out a survey, by means of a standard questionnaire, collecting data from construction-related sectors in Italy, the Netherlands, and France, to assess the effect of environmental policies on competitiveness and industrial behaviour.

This paper is organized as follows: first, we provide an overview of the main findings emerging from the literature related to the two hypotheses of the study. The next section describes the data set and the estimation methodology. We surveyed 78 European firms of building and construction sector, and operationalized the results by ordered probit models. Subsequently we present the statistical results. The probit models clearly show that a more stringent environmental regulation provides a positive impulse for increasing investments in advanced technological equipments and innovative products; moreover, the well-designed direct regulation is actually the more effective policy instrument regarding the positive impact on competitiveness. After discussing the results, we conclude with policy recommendations in the final section.

2. Theoretical background

2.1 The impact of environmental stringency on competitiveness

Economic theory provides different perspectives on the relationship between environmental policies and firms' environmental and competitive performance. The debate developed over the last fifteen years across a wide range of theoretical questions aimed at investigating *whether, under what circumstances* and *how exactly* environmental issues and firm activities are related to competitiveness. A frequently analyzed issue refers the impact of environmental regulation on firm's performance. Does a stringent environmental policy impair firms' productivity and competitiveness increasing production cost and, consequently, reducing their ability to export, or stimulate the innovation capabilities improving the resource productivity and making a firm more competitive?

To investigate this relationship, practitioners used several research methods obtaining non univocal results: sophisticated *regression analyses* searching for correlations (Brunnermeier and Cohen 2003, De Vries and Withagen 2005, Telle and Larsson 2007, Costantini and Crespi 2008), c*ase study analysis* to investigate specific casual links and circumstances through in-depth descriptions of real situations (Hitchens *et al.* 2001; Berkhout, 2003, Triebswetter and Hitchens 2005); *portfolio studies* to analyze real or model portfolios of environmentally proactive and environmentally reactive firms and comparing their respective returns (Rennings *et al.* 2003); and *event studies* to assess market responses after a positive or negative environmental event (Schaltegger and Wagner, 2003; Linn, 2006).

Essentially, we can identify three major theoretical approaches in literature.

The "traditionalist" view of neoclassical environmental economics argues that the purpose of environmental regulation is to correct negative externalities, and that, consequently, environmental regulation – in internalising the costs of the negative externalities – remedies to a market failure, while burdening companies with additional costs. Firms complying with regulation (by increasing expenditures in environmental protection) face higher production costs and reduce the competitiveness of their products on domestic and foreign market. There have been many empirical studies performed in this field, providing non univocal results supporting this relationship

(Gollop and Robert, 1983; Letchumanan and Kodama, 2000, Antweiler *et al*., 2001 Gray and Shadbegian 2003; Cole and Elliot, 2003; He 2006)

For instance, at national scale, Jorgenson and Wilcoxen (1990) found that, over the period 1974-1985, the combined effect of mandatory pollution abatement costs and investment as well as compliance with standards was to reduce the average growth rate of real GNP in the US by 0.2 percentage points. Focusing on the negative effect of environmental regulation on firm/sector's productivity, Gray and Shadbegian (2003) found that more stringent air and water regulations have a significant impact on paper mills' technological choice in the U.S. However, their results suggest that it tends to divert investment from productivity to abatement, consistent with the standard paradigm. Furthermore, the environmental regulation can have a deterrent effect on foreign direct investment: using a simultaneous model to study the relationship between FDI and final industrial SO_2 emissions in China, He (2006) found evidences for the 'pollution haven' hypothesis.

A second set of surveys argue that there is not enough empirical evidence showing that environmental regulation severely affects international trade, firms' and industry productivity and/or business location, and economists shouldn't therefore care too much about industrial competitiveness (Roberts 1992, Cropper and Oates 1993, Jaffe *et al.* 1995, Telle and Larsson, 2007, Lee 2008).

As opposed to the neoclassical perspective, a "revisionist" view states that improved environmental performance (as induced also by regulation) is a potential source of competitive advantage, as it can lead to more efficient processes, improvements in productivity, lower costs of compliance and new market opportunities (Gabel and Sinclair-Desgagné, 1993; Porter and van der Linde, 1995a; Sinclair-Desgagné, 1999). Porter and Van der Linde (1995b) suggest that environmental regulation is potentially beneficial to firms. Environmental regulation can provide incentives to change firm's production routines (technological or process innovation) in a way that leads to compliance and reduced costs - through decreased resource inputs or increased efficiency -, or can even lead to new marketable products that may be preferred by environmentally-oriented final consumers or intermediate customers. Such innovations may entirely offset the costs of compliance.

The Porter hypothesis – with particular reference to the argument of stimulating innovation through environmental regulations – has been analysed in many studies, despite the fact that often the systematic testing of the Porter model has been hampered by data problems.

Regulatory compliance expenditures are the most commonly used comprehensive measure of environmental regulatory burden on industry. However. it falls short of providing a truly exogenous measure of regulatory burden, since the level of the associated costs also depends on the nature of an industry's response to regulation (Jaffe and Palmer, 1997).

Although it sometimes is difficult to generalize empirical findings, several studies seem to confirm the Porter hypothesis. Drawing upon U.S. data, Brunnermeier and Cohen (2003) found a positive relationship between environmental regulation and environmentally-related successful patents. In addition, Popp (2006) provided evidence that the introduction of environmental regulation on sulphur dioxide in the U.S., and on nitrogen dioxides in Germany and Japan, was shortly followed by a very significant increase in the number of relevant patents. Recently, Leiter *at al.* (2009), focusing on European industry level data between 1995 and 2005, demonstrated that environmental stringency has a positive but diminishing impact on investment.

A third and more recent interpretation of the impacts of environmental policies on competitiveness is proposed by the so-called "Resource-based view" approach. According to this approach, the competitiveness of companies and industries depends on the quality and quantity of the resources available and by the ability of companies/industries to optimise their use (Fouts and Russo, 1997). The Resource-Based View explicitly recognizes the importance of *intangible assets*, such as *know how* (Teece, 1980), *corporate culture* (Barney, 1986), and *reputation* (Hall, 1992). This approach is an evolution of the Porter's approach, as it enlarges the typologies of resources that the companies and industries can rely on.

2.2 The role of the form of environmental regulation

According to the revisionist view, environmental regulation is mainly considered to be "an industrial policy instrument aimed at increasing the competitiveness of firms, the underlying rationale for this statement being that *well designed* environmental regulation could force firms to seek innovations that would turn out to be both privately and socially profitable" (Sinclair-Desgagné, 1999). Porter and Van der Linde (1995b) themselves emphasized that in order to stimulate innovation, environmental regulation should focus on outcomes and not processes (i.e. only *certain types* of environmental regulation stimulate innovation) and that "*properly designed* environmental regulation can trigger innovation that may partially or more than fully offset the costs of complying with them". The form of environmental regulation can, therefore, influence the effect of legislation on firm's behavior.

Starting from this argument, Jaffe and Palmer (1997) distinguished three distinct variants of the Porter hypothesis:

- the "weak" version of the hypothesis, asserting that environmental regulation will stimulate *certain kinds* of environmental innovations, although there is no claim that the direction or rate of this increased innovation is socially beneficial;
- the "narrow" version of the hypothesis, stating that *flexible* environmental policy instruments, such as pollution charges or tradable permits, provide firms with a greater incentive to innovate than *prescriptive* regulations, such as technology-based standards;
- and finally, the "strong" version, positing that *properly designed* regulation may induce innovation more than compensating the cost of compliance.

Lanoie et. *al*. (2007) tested the significance of the three different variants of the Porter hypothesis on the four main elements of the "causality chain" (i.e.: environmental policy - research and development - environmental performance - competitive performance). Using data from approximately 4.200 facilities in seven OECD countries they found strong empirical support for the "weak" version of the Porter hypothesis and qualified support for the "narrow" and the "strong" version.

Regarding the different forms of environmental regulation, we can identify three categories of policy instruments, depending on their *ratio* (e.g.: "Polluter Pays Principle" vs. market-oriented approach) and the degree to which they are compulsory: *direct regulation* (*command and control*), *economic instruments* and *soft instruments*.

Direct regulation includes *standards* as well as *commands and prohibitions* and can be classified into: input regulation, process regulation, and output regulation. Economic instruments include duties and tradable emission permits as well as environmental liability (Hawkins 2000). Environmental duties can take the form of taxes, charges, dues, or extra duties. Their function is either to increase the state income, to give an incentive to the change of the behavior of the regulated subject, or to support the implementation of another environmental regulation. Finally, soft instruments include voluntary industry agreements, communication and information measures as well as environmental certification schemes (both process- and product-oriented, e.g.: ISO 14001, EMAS or the EU Ecolabel).

A number of studies have indicated that direct regulation, including integrated licensing, is effective at improving environmental performance (Silvo et al., 2002; Mirasgedis et al., 2008). Such regulation has also been found to be efficient in terms of achieving positive cost-benefit ratios, through the reduction of negative externalities associated with environmental impacts (Clinch and Kerins, 2002). Focusing on their potential effect on competitiveness, empirical studies show contradicting evidence regarding innovation effects. Hemmelskamp (1999) emphasizes that the polluter has no incentive to lower emission beneath the regulated standards, as pollution produced at a lower level than the standard does not incur any cost. On the opposite, Kuntze (1999) suggest that the potential of regulation to effectively stimulate innovation depends on its specific design (e.g. standards vs. best available technologies), inclusion of dynamic aspects, coverage (e.g. exceptions, inclusion of old plants, etc.), and implementation (flexibility, enforcement, etc.).

With regard to economic instruments, Jaffe *at al*. (2002) state that the market-based approaches are likely to have significantly greater, positive impacts over time than command-and-control approaches on the invention, innovation and diffusion of desirable environmentally-friendly technologies. Moreover, the market-based instruments are the “first best” when internalizing external environmental effects, as they lead to cost-efficiency (Requate and Unold, 2003).

The effects of “soft” instruments on firms performance have been investigated by many studies, most of which concentrating on the implications of environmental management systems on environmental performance. These studies found substantial evidence supporting the positive effect of EMS adoption (King *et al.* , 2005; Newbold, 2006; Radonjic & Tomic, 2007; Arimura *et al*., 2008), while a small amount of contrasting evidence has also been collected (Dahlstrom *et.al* 2003; Barla, 2007).

Focusing on competitive effects, a recent study carried out by Iraldo *et al.* (2009), based on a sample of 100 interviewed organizations investigated whether or not an EMS implemented within the EMAS Regulation has an effect on firm performance both from an environmental and a competitive point of view. The econometric analysis shows a positive impact of well-designed environmental management system on environmental performance and, as a consequence, on technical and organizational innovations. Effects on other competitive variable as market performance, resource productivity and intangible asset are not strongly supported

In conclusion, the table 2 provides a summary of some of the most significant empirical findings we reviewed on the effects of environmental regulation on competitiveness according to the three major theoretical approaches.

Table 2 Links between environmental regulation and competitiveness – Example of measures

Theoretical Approach	Environmental Regulation		Competitiveness		Results*	Reference
	Measure	**Indicator**	**Measure**	**Indicator**		
NEOCLASSICAL	**Stringency**	*Costs of pollution control*	**Prosperity/standard of living** *(Performance)*	*Growth rate of real GNP*	--	Jorgenson and Wilcoxen (1990)
	Stringency	*Pollution abatement investment*	**Investment** *(Driver)*	*Productive (non-abatement) investment.*	--	Gray and Shadbegian (1998)
	Stringency	*Function of severity of the emission standard*	**Productivity** *(Driver)*	*Estimated cost function*	--	Gollop and Robert (1983)
	Stringency	*Pollution abatement costs*	**International trade** *(Performance)*	*Import volume and duties paid*	--	Ederington and Minier (2000)
PORTER	**Form of regulations**	*Types of environmental policy instrument*[2]	**Innovation** *(Driver)*	*R&D expenditure*[3]	+	Lanoie *et al.* (2007)
	Stringency	*Investment in pollution control equipment/total cost*	**Productivity** *(Driver)*	*Total factor productivity*	++	Lanoie, Patry and Lajeunesse (2008)

* (++ strong positive correlation; + positive correlation; -- strong negative correlation; - negative correlation).

[2] The different forms taken into account are technology-based standard, performance-based standard, input tax, emission or effluent charge.

[3] The used variable ia a dummy.

	Stringency	*Pollution control operating costs*	**Innovation** *(Driver)*	*Environmental-related patent applications*	+	Brunnermeier and Cohen (2003)
	Stringency	*Pollution control capital costs*	**Innovation** *(Driver)*	*R&D expenditure*	*not significant effect*	Jaffe and Palmer (1997)
				Patent applications	**++**	
RESOURCE BASED VIEW	**Stringency**		**Resource endowement** *(Driver)*	*Green capabilities*	**+**	Rugman and Verbeke (1998)

3. Empirical Analysis

3.1 Data Description

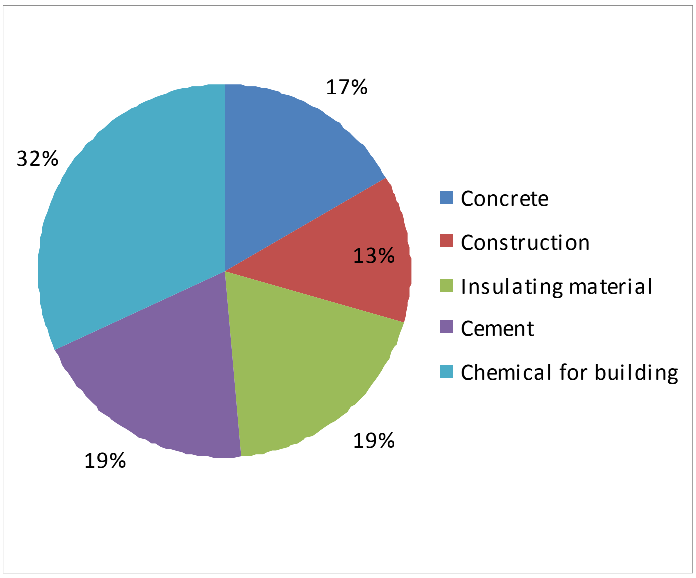
To assess the link between environmental regulation and competitive performance we used data collected by means of interviews within the EMPIRE project. The survey was implemented in the first half of 2009 in three European regions, at facility level, and aimed at retrieving information related to the performance of firms operating in the different market segments of the building & construction sector, i.e.: c*ement industry* (Italy); *chemical for building industry* (Northern Regions - Italy), *construction sector (*Northern Netherlands Provinces*)*, *insulating material sector* (Northern Italy) and *concrete* industry (Southern France).

The questionnaire, created according to the OECD survey[4] "Environmental Policy and Firm-Level Management", is composed of approximately 20 questions distributed in three sections: the first section aims at collecting information on the characteristics of organization, the second section focuses on the assessment of the effect of environmental policy stringency on firm's decisions, the third section investigates the level of competitive performance distinguishing in business performance, innovation performance, resources efficiency and intangible performance

The sampling process was carried out in three steps. In the first step, the NACE codes that refer to the investigated market segments in the B&C sector were selected. In the second step, the lists of all active organizations classified within the selected codes and located in the investigated regions were collected from different stakeholders (i.e. Chambers of Commerce and Trade Associations). Then, a random sample of 100 organizations were selected, 78 of which were interviewed. The Figure 1 shows the breakdown of the interviewed organizations according to the analyzed segments.

[4] See www.oecd.org/env/cpe/firms for further details.

Figure 1 Sample's distribution among B&C segments



Regarding the organizations' size, the sample is mostly composed of medium organizations, employing from 50 to 250 employees (44%). The small firms are 24% of the sample and the large firms only 14%.

The "age" (number of years from foundation) of the interviewed firms is equally distributed along the last 100 years: 30% of the interviewed organizations has been founded after the Second World War, another 30% dates back to more than 50 years ago, while 37% is composed of relatively "young" firms (less that 25 years old). Some differences emerge among the investigated segments: the "*young*" organizations are more concentrated in the insulating material and cement sectors (more than 66% is less that 25 years old), while the relatively *old* organizations are more concentrated in the construction and chemical for building sectors (more than 40% is older than 50 years).

Since the data from the EMPIRE study were collected using survey techniques, it is important to address the limitations of the survey data. Two of the main standard drawbacks, of survey data in general, are social desirability bias and lack of generalizability The social desirability bias refers to the fact that individuals attempt to answer survey questions in ways that they consider socially desirable (Darnall *et al.* 2008). In order to limit the potential issue associated with this kind of bias, all respondents were guaranteed anonymity and the interviewers were adequately trained to inform them to be objective. Moreover the pre-test analysis of the survey did not find any indication of social desirability bias .

Furthermore, the EMPIRE survey is not affected by the bias due to the lack of generalizability, since it targeted several market segments in multiple European regions. This approach differs from typical survey research examining organization' environmental practices and performance, which focuses on a single industry within a single country (Darnall *et al.* 2008).

3.2 Estimation methodology

In this subsection we introduce the econometric model applied to test the sign of the relationship between environmental regulatory stringency, regulation's form and competitive performance. As above mentioned, empirical studies on the relationship between environmental regulation and competitive performance on firm level are scarce and the results ambiguous. The differing methods applied in previous studies may be one reason for the ambiguous result (Telle and Larsson 2007). The regression model for plant i in year t, used to test the two hypotheses, is as follows:

$$\{Competitive\_performance_{i,t} = a + bStringency_{t-1} + \gamma EMS + \varepsilon \quad (1)$$

$$\{Competitive\_performance_{i,t} = a + bStringencyC\&C_{t-1} + \gamma StringencyMBI_{t-1} + bStringencySFT_{t-1} + \varepsilon \quad (2)$$

where Stringency is a measure of the stringency of the environmental regulation and the specific policy instruments (command & control, market based instruments, soft instruments); EMS measures the adoption of an environmental management system and *e* is an error term. The variables of each equation are explained carefully as follows.

In order to test the hypothesis 1 (*How does the environmental policy stringency affect the competitive performance of firms in the chemical for building sector)* we applied a regression analysis[5], using an ordered probit[6], and defined 5 equations with the measures of competitiveness as dependent variable (Equation n.1).

As emerge in literature, there is a variety of perspectives and levels of analysis at which the concept of competitiveness may be considered. Focusing on the firm level, competitiveness measures do relate to various aspects, such as the ability to sustain market shares, to sustain independent existence on the market or "normal" levels of profitability and returns. According to the literature, we investigated the competitive performance of the whole building & construction sector by measuring different "dimensions" of competitiveness at the firm level, represented by three key variables: market performance (Levy, 1995, Gray and Shadbegian,1998), innovation capabilities (Jaffe and Palmer, 1997, Rennings *et al.* 2006) and intangible assets (Halle 1992).

The business performance does represent the most common indicator for the "health" of an organization. The ability to generate profit in the medium run is a necessary factor for a firm's economic performance. Several indicators are used to measure this ability and, consistently, the level of competitiveness such as the *Return on Equity* (Bragdon and Marlin ,1972; Russo and Fouts,1994), the *Return on Sales* (Levy,1995) or the *Cash Flow* (Jaggi and Freedman, 1992). According to Darnall *et al.* (2008), we analyzed the organization profitability generated by lower environmental impact products (or constructed buildings) by asking to the sample organisations whether their profits had changed over the past three years. Respondents replied using a five-point scale, indicating whether during the last three years revenue was "so low as to produce large losses," "insufficient to cover our costs," "at break even," "sufficient to make a small profit," or "well in excess of costs." (GREEN_PERF). The focus on green business performance is justified since specific environmental policy instruments can encourage a firm to produce lower environmental impact products, such as green public procurement or eco-labels. Regarding the investigated sector, we can mention several examples: varnishes and paints without solvents, materials with higher insulation potential, buildings with high energy efficiency performance, etc.

[5] In statistics, regression analysis refers to techniques for the modelling and analysis of numerical data consisting of values of a dependent variable and of one or more independent variables. The dependent variable in the regression equation is modelled as a function of the independent variables, corresponding parameters ("constants"), and an error term. The error term is treated as a random variable and represents unexplained variation in the dependent variable

[6] The ordered probit is a generalization of the popular probit analysis, used for ordinal multinomial dependent variables.

The second competitive measure refers the innovation capability. Innovation is a primary source of economic growth and the environmental innovation is a key factor for pollution reduction and prevention. Different types of models, which lead to different empirical predictions, can explain the development and persistence of innovation at the firm level (Duguet and Monjon, 2004). According to the vision of the innovation process of Rennings *at el.* (2006), we analyzed innovation by asking to environmental managers whether their organization had changed the investments in environmental technologies (INN_TECH) and in environmental products (INN_PDT) over the past three years. Respondents replied using a five-point scale, indicating whether the investments were "significantly decreased," "decreased", "stayed about the same", "increased" or "significantly increased".

The last measure of competitiveness used in our model is the intangible assets. Intangible resources include reputation, technology and human resources; the latter also encompass culture, training and "expertise" of employees, and their commitment and loyalty (Grant, 1991). As these resources are not productive on their own, the analysis also needs to consider a firm's organizational capabilities, i.e. its abilities to assemble, integrate, and manage these bundles of resources. To test hypothesis 1 we focused on the personnel motivation (PERS_MOT) and competence of technicians (COMP_TECH).

Although it would be ideal to use quantitative data for measuring some competitive performance such as market performance or investments in innovation, the use of self-reported data is not uncommon in related literature (see for instance Dasgupta 1998, Henriques & Sadorsky 2006, Khalid et al. 2004, Gangadharan 2006, Iraldo *et al.* 2009).

Regarding the independent variable of first equation, the stringency of environmental regulation may be operationalized in numerous ways: compliance costs, the number of new regulations taking effect, discrepancy between non-constrained emissions and actual emissions, and the number of inspections (Telle and Larsson 2007). In our study we use the number of inspections (INSP_FREQ) as indicator of regulatory stringency for several reasons. First, previous studies have used inspection as measure of stringency and found a positive relation with emission reductions (e.g. Magat and Viscusi, 1990; Laplante and Rilstone, 1996). Second, the frequency of inspection is often determined by specific EU environmental laws (such as the IPPC Directive and the ETS Directive) that regulate the impacts of the potentially most environmentally dangerous plants. Third, I checked the existence of a correlation between the inspection frequency and the perception of stringency of the environmental policy regime[7]. The result of the Spearman correlation test measuring the level of interdependence of two variable (the interval is from -1 – negative dependence – and +1 – positive dependence) is high - 0.85 – and significant.

Finally, I considered as explanatory variable also the adoption of an environmental management system (EMS). The motivation for this choice relies on the fact that an EMS is an instrument that improves at firm level the degree of compliance with the environmental regulations (Hillary 2004, Daddi *et. al*. 2010). The EMS adoption, in fact, stimulates the organization to monitor, handle and predict the applicability of a new law and helps the organization to comply with it and manage it as an opportunity. As exogenous variables we considered also the segments of the B&C sector of operation, in order to capture the effect of external context and its possible implications on the company's decision-making (and on its performance),.

To test the hypothesis 2 (*How does the form of environmental regulation affect the competitive performance of firms in the building and construction sector?)* I used an ordered probit model and define six equations, one for each measure of firm's competitiveness (Equation n.2). Compared with the equation n.1 we considered also a measure of organization profitability (BUSS_PERF), to capture the capacity of an environmental policy instrument to influence the overall firm's performance and the level of corporate reputation (REP) to investigate if the adoption of an environmental practise (as a consequence of an environmental policy instrument) may have an effect on firm's image.

In order to explore the effect of form of environmental regulation, according to what is suggested by the OECD survey (2003), I measured the perceived relevance and stringency of specific environmental regulations, by asking to the interviewed

[7] In order to measure the general perception of stringency of the environmental policy regime, we asked to the environmental managers: *How would you describe the environmental policy regime to which your facility is subject?*. They replied choosing one of the following answers: 1) Not particularly stringent, obligations can be met with relative ease; 2) Moderate stringency, require some managerial and technological responses; 3) Very stringent, has a great deal of influence on decision-making in the organization

organizations *to assess a set of* ***environmental policy instruments*** *in terms of their impacts on their own production activities.* The proposed set of environmental policy instruments included direct regulations (technology and performance based standards), economic instruments (i.e. emissions and input taxes) and soft instruments (i.e green public procurement and demand information measures). Then, I selected one environmental policy instrument for each category since the high and significant correlation between each couple of instruments: technology based standards (TECH_STD) for direct regulation (command and control); input taxes (INP_TAX) for economic instruments and green public procurement (GPP) for soft instruments. Using the answers to specific questions I built a set of categorical variables for measuring both the competitiveness of firms and the perceived policy stringency.

The Table 3 provides descriptive statistics for the study's variables.

Table 3 Descriptive statistics

	Mean	Std.Dev.	Minimum	Maximum	NumCases
BUSS_PERF	4	.8271702	1	5	77
GREEN_PERF	3.246753	.7461453	1	5	77
INN_TECH	3.782051	.8922092	1	5	78
INN_PDT	3.448718	.8001207	1	5	78
REP	3.205128	1.231185	1	5	78
PERS_MOT	3	1.162174	1	5	78
COMP_TECH	3.103896	1.273045	1	5	77
INSP_FREQ	1.171053	1.445805	0	5	76
TECH_STD	2.565789	.6394899	1	3	76
GPP	1.746269	.8410542	1	3	67
INP_TAX	2.383562	.7384318	1	3	73
EMS	.3461538	.4788222	0	1	78

4. Results

The results of the model application carried out in the analysis provided some evidence relating to the Hypotheses described above.

4.1 The impact of environmental stringency on competitiveness

Regarding the first hypothesis – the environmental policy stringency affects the competitive performance at firm level - the results prove that a strong assumption of the Porter's theory is true for the building and construction sector.

The results, in fact, deliver good reasons to believe that there is a positive relationship between the stringency of environmental policies, measured as the inspection frequency, and some measures of competitiveness at firm level. Crucially, the higher is the number of environmental inspections, the higher is the probability that an organization increases the investments both in technical and product innovation (the sign of coefficients is positive and significant respectively at 99% and 95%). In other words the results statistically support the hypothesis that environmental policies, when effective (i.e.: stringent and implemented by way of a strong controlling system), are able to affect mostly those competitive factors related to innovation capabilities by the firm. This is basically explained by the fact that environmental regulation often sets requirements in terms of emission standards or technological standards that are able to induce the development of new technologies and techniques by the firms that are subject to it. Moreover, the need to develop or adopt new technologies implies for the firms the need to rely on trained and skilled personnel, who should be capable of facing up to complex and knowledge-intensive innovation processes. The model, in facts, proves that a stringent regulation determines an improvement in the competence of technicians (the positive relation is statistically supported at 95%).

A very interesting result is the positive and strong significant effect of stringency on the improvement in the business performance generated by green products. Although difficulty of isolating the effect of regulation on business performance is high (López-Gamero, 2009), avoiding confounding factors related to the product's quality, marketing strategy and so on, the results evidence that a more stringent regulation, that can also be interpreted as an increase of community's awareness to the environmental issues, stimulates the firms to concentrate efforts on product at lower impact on the environment and get, as a consequence, good responses by the market.

Finally, the EMS adoption does play a positive influence just in the relation between environmental regulation and technical innovation, confirming for the building construction sector what emerged in the related literature as well (the coefficient is very high but is weakly supported at statistical level) (Rennings *at al.* 2006, Iraldo *et al.* 2009). The model, furthermore, shows, as emphasised by many authors (Biondi *et al.* 2004), that an EMS adopters very seldom obtains positive feedbacks directly from the market while the main recognizable benefits refers intangible assets such as personnel motivations.

Regarding the effects of the investigated segments of the building & construction sector, some interesting evidence emerged. The chemical for building sector has a positive influence on the effects on product innovation and green business performance, while the concrete sector has a positive influence on technical innovation and green business performance.

Table 4 Ordered probit models to investigate the links between environmental stringency, EMS adoption and competitive performance (Hypothesis 1)

Dependent Variable	**Innovation performance**				**Business performance**		**Intangibles performance**			
	Technical Innovation		**Product Innovation**		**Green business performance**		**Personnel motivation**		**Competence of technicians**	
Independent Variable	*Coefficient*	*z*	*Coefficient*	*z*	*Coefficient*	*z*	*Coefficient*	*z*	*Coefficient*	*z*
Inspection frequency	**0.3978**	**3.36*****	**0.2310**	**2.15****	**0.3877**	**3.06*****	-0.0700	-0.70	**0.2186**	**2.18 ****
EMS adoption	**0.6676**	**1.93***	0.2585	0.80	-0.5018	-1.32	**0.9409**	**2.97*****	0.4459	1.57
Chemical sector	.4329	0,84	**0.9326**	**1.97****	**2.1848**	**3.08*****	-0.0988	-0.22		
Cement sector	**1.2420**	**2.12****	-0.6788	-1.28	0.4827	0.80	.6318	1.25		
Concrete sector	**1.3131**	**2.42****	0.5854	1.19	**2.6099**	**3.52*****	.1258	0.28		

Insulating material sector	.6114	1,22	0.6701	1.43	**2.7776**	**3.82*****	.2818	0.65		
LR chi2	42,23***		22.24***		40.50***		15.98**		11.66***	
Pseudo R-square	0.2329		0.1243		0.2508		0.0704		0.0493	

*** p < 0.01 ** p < 0.05 * p < 0.1

4.2 The role of the form of environmental regulation

As we above mentioned, according to Porter and Van der Linde (1995), the effect of environmental regulation on firm's competitiveness, in particular on its innovation capabilities, may depend on its design. In other words well *designed* environmental regulation could force firms to seek innovations that would turn out to be both privately and socially profitable (Sinclair-Desgagné, 1999). The second step of the model was, consequently, the attempt to understand if and how these effects on competitiveness change according to different types of environmental regulation.

Regarding these effects, some interesting considerations emerge from the results of the ordered probit regression, applied to test if the different types of environmental regulation influence firm's competitiveness.

On one hand, they confirm with respect to the most "conventional" forms of environmental policies the relevance of direct regulation: the high impact of technology-based standards on firm's production activities has a positive effect on the increase of investments in technical innovation, and the intangible assets (in particular with the competence of technicians). This first result is quite expected and reasonable, insofar as direct regulation usually relies on standards and requirements which are focused on the environmental performance (e.g.: limits to emissions) that can be achieved by way of different technological solutions or, in the most recent regulative forms (e.g. the IPPC Directive), they make direct reference to the BAT (Best Available Techniques) for the sector. As a consequence, firms tend to respond to this kind of regulations by means of investments in cleaner technologies and involvement of trained and expert technicians.

The positive relation between technology based standard and business performance is consistent with the studies in other sectors on the cost-effectiveness of some innovative direct regulation such as IPPC regulation (e.g. Clinch and Kerins, 2002). If emission costs are considered as production inputs (Telle and Larsson, 2007), then a technology-based regulation clearly leads to improvements in production efficiency. The increase of abatement cost can be widely offset by an increase of resource efficiency and generate a positive business performance. This relation is actually not univocal: for example a recent survey on Irish Pharma found that implementation of stringent direct regulation over a wide trading area (EU IPPC Directive) has lead to improved competitiveness at this level through the creation of a 'level playing field', but the same respondents perceived a negative effect on global competitiveness, and suggest that the efficiency of IPPC regulation could be improved (Styles *et al*. 2009)

On the other hand, the relevance of voluntary instruments such as GPP is strongly related with competence of technicians and investments in technological innovations reputation (even if this relation is weakly supported, $p<0.1$). These results provide rather clear indications. First, it is confirmed that environmental policies, even if applied by way of "soft" instruments, are able to influence mostly the innovation abilities of the firm. Moreover, they confirm an incomplete efficacy of recent promotion of GPP by the European Commission (see for instance the Directive 2004/18/EC and 2004/17/EC) and some Members States Government, such as Italy (at central and local level), that has encouraged its diffusion among public authorities and private companies. Crucially, even if the soft instruments (GPP, but the same can be said for certification schemes) generate an incentive to innovate via a market dynamic, they still produce a very limited effect on market-related competitive performance. The only competitive variable that these instruments are able to strongly affect is firm's reputation and image, but they are not able to prompt a real increase in the market performance (such as: increase in sales or market shares).

Finally, it is interesting that economic instruments (such as input taxes) have a negative impact on business performance, as well as on realisation of green business opportunities. These instruments (tax on input or output), conceived in theoretical terms as pigouvian taxes, should be able to stimulate a firm to improve its resource efficiency, but the absence of a relation with "investment in innovation" clearly indicates that they are still inefficient from this point of view. So the bottom line is that these instruments generate costs (the piguovian tax on production output), without being capable of stimulating innovation leading to cost efficiency. This result is only apparently against the Porter hypothesis, since it does highlight that a not well-designed economic instrument is unable to positively affect firm's competitiveness. In other words the higher cost per unit of production, implied by any environmental tax or tariff, does negatively affect the business performance, as it is not more than balanced by other positive factors (such as the induced savings generated by environmental improvements and increased eco-efficiency).

Table 5 Ordered probit models to investigate the links between forms of environmental regulation and competitive performance (Hypothesis 2)

Independent Variable	**Innovation performance**		**Business performance**				**Intangibles performance**					
	Technical Innovation		**Business performance**		**Green business performance**		**Personnel motivation**		**Competence of technicians**		**Reputation**	
Independent Variable	*Coefficient*	*z*	*Coefficient*	*z*	*Coefficient*	*z*	*Coefficient*	*z*	*Coefficient*	*z*	*Coefficient*	*z*
Technology based standards	0.664	**2.58 ****	0.524	**2.05 ****	0.128	0.50	.533	**2.25 ****	0.719	**2.96 *****	0.575	**2.43 ****
Green public procurement	0.530	**2.75 *****	0.112	0,58	0.066	0.36	.262	2.25	0.558	**2.96 *****	0.323	**1.81***
Input taxes	-0.199	-0.95	**-0.877**	**-3.70 *****	**-0.544**	**-2.55 ****	-.111	-0.57	0.208	1.05	0.091	0,47
LR chi2	21.89***		16.41***		6.77*		11.43***		31.43***		16.57***	
Pseudo R-square	0.1418		0.1117		0.0480		0.0612		0.1605		0.0842	

*** $p < 0.01$ ** $p < 0.05$ * $p < 0.1$

5. Conclusion

In this paper I have tested an empirical model based on a probit regression in order to provide evidence of the relevance of the Porter and van der Linde hypothesis also for the building and construction sector.

According to Costantini and Crespi (2008) empirical results show that a more stringent environmental regulation provides a positive impulse for increasing investments in advanced technological equipments and innovative products; moreover, it stimulates the qualitative improvement of human resources in term of technical competence. Furthermore, new evidence refers the potential ability of environmental regulation to stimulate the realisation of green business opportunities

Despite the outcome of many studies identified in literature (Hitchens *et al*., 2001; Ederington and Minier, 2003; Honkasalo *et al*., 2005; López-Gamero *et al*., 2009), our study clearly showed that direct regulation has a direct and significant effect on some competitive performance of companies. More precisely, direct regulation has an effect on firms' innovation capabilities. Furthermore, the level of stringency and the intensity of the monitoring and control activities are a powerful incentive to improve the environmental and competitive performance. Some new forms of direct regulation, focusing more on technological standards than on emission limits, seem to be particularly effective on competitive performances (e.g. the IPPC Directive approach). This means that policy makers should be maintain direct regulation as one of the most effective environmental policies, keeping in mind that if properly conceived, it can produce positive effects also on competitiveness.

Economic instruments were also found to have an important influence on the operations of firms belonging to building and construction sector. Our findings confirm a traditional viewpoint on the effects of this kind of policy measure: they do negatively affect business performance. This assumption is strongly discussed by a large part of the literature (Jaffe *at al*. 2002, Requate & Unhold, 2003), and it is supported (even if weakly) by the model. This emphasizes the need of using economic instruments (especially pigouvian taxes) taking into account that they can hamper firms' competitive performance. Therefore, these policy instruments should be applied together with compensation measures, such as subsidies for "sensitive" companies (e.g.: SMEs) or for the best performing companies under the environmental point of view (subsidising the "champions" could lead to an emulative effect).

Finally, the study found that soft instruments are beginning to be effective on competitiveness, but their influence is still not very high, especially on those performance on which they should have the main implications, i.e.: those most connected to the market dynamics. Soft instruments are able to stimulate innovation abilities by the firms and to improve "intangible assets", such as reputation and technical competence, but they are not capable of changing market trends or demand pressure (by orientating them towards more sustainable products). Although they were conceived to enhance the competitiveness of participating firms, there is no evidence that this has translated into tangible business performance improvements yet, possibly owing to low government support, many competing schemes, and questionable verifiability. The failure of "soft instruments" is due to a lack of awareness and availability to behave in a more sustainable way in market choices by intermediate customers and final consumers, more than to drawbacks or misuse in their application. Therefore, the policy makers should strengthen the use and diffusion of "soft instruments" also by reinforcing the demand-side i.e. by creating a "demand capacity" in the intermediate and final markets for more sustainable products and services (e.g.: by way of information and sensitisation public campaigns, enacting GPP-supporting policies and incentives, ecc.).

CHAPTER 3: Is an Environmental Management System able to influence environmental and competitive performance? The case of the Eco-Management and Audit Scheme (EMAS)in the European Union[8]

Abstract

The EMAS Regulation (Reg 761/01 EC) is EU scheme implemented by the European Commission since 1993 and it is for the implementation of an Environmental Management System (EMS) by any organization. The EMS was originally proposed by the European Commission and by the ISO as the frontrunner of a series of policy tools that enable companies to simultaneously pursue environmental objectives and competitive targets in a synergetic way.

Based on the unique dataset of the EVER project, this paper investigates whether or not an EMS implemented within the EMAS Regulation has any effect on firm performance both from an environmental and a competitive point of view. Our econometric analysis shows the positive impact of a well-designed environmental management system on environmental performance and, as a consequence, on technical and organizational innovations. Effects on other competitive variables such as market performance, resource productivity and intangible assets are not strongly supported.

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1. Introduction

The Environmental Management System (EMS) is an increasingly diffused tool among organisations operating in different sectors, thanks to the drive and impulse from voluntary certification schemes such as EMAS and ISO 14001. These schemes provide a third-party guarantee of environmental "excellence", which is able to give an advantaged position (with respect to their competitors) to those organisations that, by adopting EMAS or ISO 14001, commit themselves to improve the environmental performance.

This article departs from the starting point of these three basic principles and tries to demonstrate the link between a) EMAS, one of the most diffused and credible environmental voluntary certification schemes, b) the environmental performance that it can provide as a result of its management system implementation and c) the advantages that EMAS-registered organisations can have when facing their competitors in the market arena.

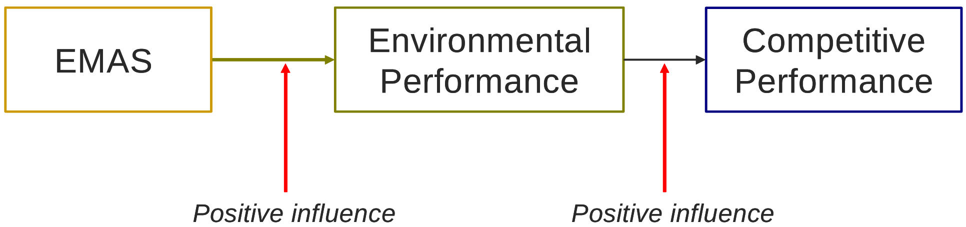
Extensive theoretical and empirical research on the benefits of EMS has been carried out to date. Most of the empirical research analyzed the effect of formal and informal EMSs on environmental and economic performances, focusing on best practices and case studies (Fresner & Engelhardt, 2004; Hillary, 2004; Newbold, 2006) or using descriptive analysis of samples (Fresner & Engelhardt, 2004; Zenga *et al.*, 2005; Radonjic & Tominc, 2007) of firms. These approaches provided very useful evidence and indications to practitioners for implementing effective EMSs, but do not provide sufficient proofs to generalize their findings and, therefore, to understand if a managerial tool, such as the EMS, is really able to guarantee environmental and competitive improvements.

Moreover, the evidences emerging from these studies are not always univocal. Most of them, based on best practices, found that formal EMS implementation, such as ISO 14001 or EMAS, provide benefits on environmental and economic performance (Fresner & Engelhardt, 2004; Newbold, 2006; Zenga *et al.*, 2005; Radonjic & Tominc, 2007), but other studies revealed that the proclaimed benefits are sometimes very far from being quantifiable or even really perceived (Ghisellinia & Thurston, 2005).

In order to overcome the limits of the above mentioned studies, according with the recent literature on EMSs (Rennings *et al.*, 2006; Barla, 2007; Arimura *et al.*, 2008; Darnall *et al.* 2008a), we applied econometrical tools for testing the effects of EMAS adoption on environmental and competitive performance using a representative sample of firms.

More specifically, our work is a two-step model that aims at identifying and evaluating the positive influence connecting EMAS to competitive performance. The first step aims at testing if EMAS and, more in general, an Environmental Management System, is really able to produce an improvement in environmental performance as perceived by the organisation. The second step aims at investigating if and how this performance, especially when strengthened by a third-party registration such as EMAS, can really give an organization better position on the four most important competitive leverages: innovation, marketing, productivity and intangible assets.

Figure 2 The conceptual framework



2. Theory and Hypothesis

2.1 Using EMAS as a managerial tool to improve the environmental performance of a firm

The adoption and use of environmental management systems by companies has awaken a considerable interest in scholars and researchers in the recent years, especially when considering the increased popularity and diffusion of EU and international standards such as EMAS and ISO 14001.

With regards to the effects of EMS on the overall environmental performance, a substantial amount of evidence has been collected. We report some of the most recent and interesting evidence, emerged by studies that used an econometrical approach.

By examining a sample of 7,899 facilities drawn from the population of U.S manufacturing facilities from the years 1995-2001, King *et al.* (2005) found evidence that EMS adoption results in improved environmental performance, measured as a logarithm of the toxicity-weighted sum of all Toxic Release Inventory. In another study using Japanese facility-level self-reported data from an OECD survey, Arimura *et al.* (2008) estimated the positive effects of ISO 14001 on three environmental impact improvements.

Yet, a small amount of contrasting evidence has also been collected. Findings have emerged from other studies that formal EMSs (e.g.: ISO 14001 and EMAS) do not substantially affect a firm’s environmental performance (Dahlstrom *et al.*, 2003; Andrews *et al*., 2003). One of the most significant empirical studies used a panel data of 37 pulp and paper plants in Quebec over the period 1997-2003 which identified no meaningful evidence of reductions in pollution after obtaining ISO 14001 certification (Barla, 2007).

Whether or not an EMS proves to be beneficial, can strongly depend on time. It must be taken into consideration that an organization will need time to adapt an EMS to its specificities. That is, in order to obtain effective operation and achieve positive results in terms of environmental improvement, an organization must set objectives and plan managerial activities and technological investments. A structured EMS, as defined by the ISO 14001 standard and the EMAS Regulation, is a part of the overall management system which include organizational structure, planning activities, responsibilities, practices, procedures, processes and resources. Consequently, all of these elements must work together in order to guarantee the continuous improvement of environmental performance. This inevitably brings about changes in a firm’s managerial and operational structure. These widely agreed-upon considerations may give rise to the simple argument that formal EMS implementation (e.g.: according to EMAS Regulation) needs time to generate positive effects on environmental performance. Our analysis aims to provide empirical evidence of the positive relations between the maturity of a certified EMS and environmental performance improvement..

Hypothesis 1. Organizations with a mature and certified EMS (i.e.: EMAS registered) have better environmental performance than those without.

2.2 Environmental Planning and EMS

The application of an EMS scheme may not be a sufficient condition to guarantee improvements in an organization’s environmental performance. In order to render it an effective tool, a “new philosophy” must permeate all the hierarchical levels in the organization that adopts an EMS: from the upper management to operational personnel.

First, this new philosophy rests on the capability to indentify and analyze the critical elements of management, define adequate *corrective actions* and carrying out effectively what is planned. The planning concept includes all these elements, representing, in fact, the first step of the so-called “Deming cycle” (PDCA Plan-Do–Check–Act) and, therefore, a cornerstone of an EMS.

When we look at the concept of “planning”, we should interpret it in an extended way: planning means organizing resources and defining the ways for their utilization, setting up the innovative operational activities and developing the relations with stakeholders or anything else effecting the firm’s environmental performance. In other words, a firm’s “planning capabilities” is a crucial factor for implementing a really effective EMS (Biondi *et al*., 2000).

The adoption of more innovative activities or tools, which are often correlated to EMS adoption, can be interpreted as an evidence of planning capabilities and, consequently as a way to strengthen the effectiveness of an EMS.

For instance, in a study on Italian facilities between the years 1994-1997, evidence emerged that with the implementation of specific environmental management tools such as compensation schemes and award schemes, SO_x and NO_x pollution rates strongly improved (Siniscalco *et al.*, 2000). In similar studies, Arimura *et al.* (2008) and Annandale *et al.* (2004) demonstrated the positive effect of the publication of environmental reports on environmental performance at firm level. Publishing environmental reports enhances communication between a firm and its stakeholders (e.g.: employees, shareholders, financial institutions, investors, consumers, environmental NGOs, governments, and local residents) and improves its corporate image (Arimura *et al.*, 2008). This transparency shows a high level of awareness and involvement of an organization towards environmental management approach and, as a result, towards the effectiveness of the EMS itself .

Moreover the level of competence and awareness of personnel performing tasks which might have a significant environmental impact is a key-indicator of an effective planning capability within an EMS (Ferreira *et al.* 2006). Both ISO 14001 and EMAS schemes provide thorough descriptions of environmental training activities: “The organisation shall identify training needs with its environmental aspects and its environmental management system; it shall provide training or other action to meet these needs” (European Commission, 2006). In their analysis of Mexican manufacturing facilities, Dasgupta *et al.* (2000) found that environmental training to non-environmental workers as well as environmental specialists resulted in positive effects on self-reported degree of compliance.

As mentioned above, previous studies have investigated only in an indirect way the effectiveness of “planning” (and of the whole EMS), meanwhile our study focuses directly on the organization’s planning capability and, more specifically, on the way in which it can influence the EMS effectiveness. The ability of an organization to achieve its environmental targets strongly depends on its ability to pursue the continual improvement of the environmental performance by effectively planning the organisational activities, the economic investments and the technological measures that are needed to achieve it.

Hypothesis 2. Organizations that are able to plan effectively their environmental targets have better environmental performance improvement

2.3 Green Supply Chain Management and EMS

EMAS, differently from other EMS standards, stresses the fact that, in order to be registered, an organization has to manage and improve not only direct environmental aspects, but also "indirect" ones (Handfield *et al.* 2002). The EMAS Regulation defines an indirect environmental aspect *as an element of an organisation's activities, products or services that has or can have an impact on the environment and which can result from the interaction of an organization with third parties and which can to a reasonable degree be influenced by an organization* (European Commission, 2008). The role of the third party (usually an "intermediate" actor such as a supplier or a contractor) with whom the organization shares management control (or whom it can influence), is therefore crucial in guarantying the improvement of the environmental performance relating to indirect aspects.

Indirect environmental aspects may include, for example: product-related issues (design, Research & Development, packaging, transportation, use and waste recovery/disposal), capital investments, granting loans and insurance services; choice and composition of services (e.g. transport or the catering trade), product range compositions and the environmental performance and practices of contractors, subcontractors and suppliers.

By focusing their EMS on the supply chain management, some organizations in recent years have begun relying on their suppliers to improve their environmental performance and create value for them-selves and their customers (Carnimeo *et al.*, 2002).

Generally, the most common Green Supply Chain Management (GSCM) practices consist in assessing the environmental performance of suppliers, in requiring suppliers to undertake measures that ensure the environmental quality of their products or in evaluating the cost of waste in their operating systems (Handfield *et al*., 2002). The relationship between EMS and GSCM practices has potentially complementary and significant implications for an organization's environmental performance, because when applied together (and in a synergetic way), they offer a more comprehensive means for defining and establishing sustainability among organizations networks (Darnall *et al.*, 2008b).

The positive effect of GSCM practices on environmental performance is relatively supported by empirical evidence. Geffen and Rothenberg (2000) analyzed three case studies of US assembly plants and stated that strong partnerships with suppliers, supported by appropriate incentive systems, help the adoption and development of innovative environmental technologies. In addition to this, interaction with suppliers' staff, partnership agreements and innovation development lead to improvements in environmental performance, maintaining production quality and cost goals. The improvement in environmental performance provided by intensive inter-firm relations could be facilitated by firms proximity (Iraldo & Frey, 2007). Using empirical results from 186 respondents on GSCM practice in Chinese manufacturing enterprises, Zhu and Sarkis (2004) found that a higher level of adoption of GSCM practices (environmental audit for suppliers' internal management, environmental requirements for purchased items, ISO 14001 certification, cooperation with suppliers and customers for environmental objectives) leads to higher environmental performance improvement.

Our analysis intends to provide a further contribution to empirical evidence already existing in literature on positive relations between encouraging suppliers to adopt environmental measures and environmental performance improvement.

Hypothesis 3. Organizations which encourage their suppliers to adopt environmental measures have better environmental performance improvement

2.4 EMAS as a managerial tool for improving competitive performance at firm level

The economic literature provides different perspectives and theories on the relationship between environmental policies and corporate environmental performance on the one hand and, on their effects on firms' competitive performance, on the other. The debate in the last fifteen years over a wide range of theoretical questions investigates *whether*, *under what circumstances* and *how exactly* environmental issues are related to competitiveness. Summarizing, we can identify three major theoretical approaches in the literature.

The “traditionalist” view of neoclassical environmental economics argues that the purpose of environmental regulation is to correct negative externalities, and that, consequently, environmental regulation (internalising the costs of the negative externality) corrects a market failure, while burdening companies with additional costs. Firms complying with regulation (by increasing expenditures in environmental protection) face higher production costs and reduce the management time devoted to pursuing other tasks. This is deemed to have effects on the competitiveness at firm and sectoral level (Gollop and Robert, 1983; Gray and Shadbegian, 2003; Ederington and Minier, 2003).

As opposed to the neoclassical perspective, a “revisionist” view states that improved environmental performance is a potential source of competitive advantage, as it can lead to more efficient processes, improvements in productivity, lower costs of compliance and new market opportunities (Gabel and Sinclair-Desgagné, 1993; Porter and van der Linde, 1995; Sinclair-Desgagné, 1999).

A third and more recent interpretation of the impact of environmental policies on competitiveness is proposed by the so-called “Resource-based view” approach. According to this approach, the competitiveness of companies and industries depends on the quality and quantity of the resources available and by the ability of companies/industries to optimise them (Fouts and Russo, 1997). This approach is an evolution of the Porter approach, as it enlarges the typologies of resources that the companies and industries can rely on.

According to this revisionist view, environmental regulation is mainly considered to be “an industrial policy instrument aimed at increasing the competitiveness of firms; the underlying rationale for this statement being that *well-designed* environmental regulation could force firms to seek innovations that would turn out to be both privately and socially profitable” (Sinclair-Desgagné, 1999).

An abundant literature analyzes the *forms of regulation* as well as the *design of environmental policy instruments* for their impact on innovation and competitiveness (Andersen & Sprenger, 2000; Lanoie *et al.*, 2007). Economists have traditionally placed environmental policy instruments into two categories: those providing firms with relatively less flexibility (e.g.: Command & Control instruments) and those providing firms with incentives to look for more effective ways of achieving the environmental objective.

EMSs, and in particular the EMAS Regulation, belong to the second category (the so-called "soft instruments") based on a voluntary approach, negotiation and shared responsibility of the actors involved.

The general impression deriving from the analysis of the evidence emerging from previous studies is that EMS adoption, and in particular certified EMS, is actually able to exert a positive influence on competitiveness, even if the effective relevance in supporting it is not certain.

For instance, with reference to the direct effects of EMAS adoption on competitiveness, a recent European study (Rennings *et al.*, 2006) investigated the impact of the its different characteristics on technical environmental innovations and economic performances in Germany, by analysing data from a unique dataset of EMAS-registered sites. The study identified a weak relationship between EMAS and some indicators of market success. However, a positive impact on the increase of turnover and exports is found, especially when a company is able to achieve significant learning by adopting EMAS. Hence, the authors concluded that a better linkage between environmental management and innovation management could improve competitiveness.

On the other hand, the findings emerging from literature that show a positive relation between EMS, or certified EMS and competitiveness, are mainly anecdotal and just few empirical research found generalizable results (Clausen *et al.*, 2002).

The fact is that simply adopting EMS, even if in compliance with a *third part designed* standard, such as ISO 14001 or EMAS, does not *per se* assure an improvement in competitive performance. The relation is neither direct nor "automatic", but depends on the effects of the EMS on the organisation environmental performance. In other words, if only an EMS achieves the aim for which it was designed, or the continuous improvement of environmental performances, a positive effect on firm competitiveness could be attained.

Following this conceptual framework, we therefore argue that EMAS represents an effective tool in improving organization's environmental performance and, only as a consequence, its competitiveness.

The few empirical studies addressing the relation between environmental performance and competitiveness focused, mainly, on the economic performance at firm level. The evidence is very mixed on this subject: some studies found a weak or a non statistically significant relation between economic and environmental performance, while other studies reached the opposite conclusion.

For example, Jaggi and Freedman (1992), by analyzing data from American pulp and paper plants, investigated the association between water pollution and economic and market performance. Using the Pearson Correlation test for three different time periods, the study provides weak evidence that firms with good pollution performance are not being viewed positively by the market because of the negative association between pollution and economic performance in the short period. The results show that market performances indicate that the Price-Earnings ratio is negatively associated with pollution performance over a short period of time.

Similar findings emerge from the study carried out by Levy (1995). Using data from several sources, Levy found that firms with more significant reductions in toxic emissions tended to have poorer financial performance - measured as "return on sales" and "return on equity and sales" -, although the relationship was not statistically significant.

On the contrary, there is also evidence to suggest that good environmental performance can help enterprises get better economic result. Hart and Ahuja (1996) report that efforts to prevent pollution and reduce emissions drop to the "bottom line" (ROS, ROA, ROE) within 1-2 years of initiation: operating performance (e.g., resource productivity or savings leading to efficiency) is benefited in the following year, while at least 2 years are needed before financial performance is affected. Klassen and McLaughlin (1996) used the "financial event methodology" to prove the positive link between environmental and financial performance. Also Al-Tuwaijiri *et al.* (2004) demonstrate, by a simultaneous equation model, that good environmental performance is significantly associated with good economic performance.

In our study, as we aforementioned, we focus on EMAS and on its capability to improve the environmental performance of registered organisations and, consequently, their competitiveness on the market. The aim is to gain insights on how the environmental performance improvements enable the EMAS-registered organizations to obtain positive feedbacks from the final consumer or the intermediate client. In order to measure the competitive performance at firm level, we refer to the conventional variables used in the literature, such as market shares (Gray and Shadbegian, 2003), increase of sale and turnover (Levy, 1995), innovation (Jaffe and Palmer, 1997), image and customer satisfaction (Halle 1992), etc. Hence, some dimensions are closely linked to the market (e.g: market shares and sales) or to internal efficiency (resource productivity), while others refer to "immaterial" and non-quantifiable assets (e.g: image, customer satisfaction, innovation), being nevertheless crucial for the overall competitive performance of organisations.

Hypothesis 4. EMAS-registered organizations with higher environmental performance have better competitive performance

3. Empirical analysis

3.1 Data description

In order to evaluate the abovementioned hypotheses, we rely on data collected within the EVER study (*Evaluation of EMAS and Ecolabel for their Revision*) carried out by a consortium of universities, research institutes and consultants coordinated by IEFE (the Institute for Energy and Environmental Policy and Economics of the "Bocconi" University in Milan, Italy) on behalf of the European Commission – DG Environment. The aim of the EVER study (IEFE Bocconi *et al.*, 2006) was to provide recommendations to the European Commission for the second revision of the Eco-Management and Audit Scheme. The results of the study, especially those related to the effects of EMAS on environmental performance and competitiveness, have been considered by the European Commission and by the Member States as a milestone on which to ground the revision process (the study is cited in the Explanatory Memorandum of the new Regulation proposal- see reference 21 for details).

Data were collected between spring and summer 2005 by way of interviews ("on-site" and by telephone), based upon a standard questionnaire. The questionnaire is composed of approximately 40 questions distributed in four sections: the first section focuses on the organization characteristics, the second investigates the adoption of environmental practices and their effects on environmental performance, the third section identifies the barriers for EMAS adoption and the last section evaluates the effects of these instruments on the adopters' competitive performance.

Moreover, the standard questionnaire was adapted, in a modular way, to several different typologies of interviewees, according to their specificities. In particular, the interviewed subjects were: EMAS stakeholders, EMAS adopters, EMAS no-adopters and EMAS public institutions. Some of the questions were, indeed, reformulated to investigate specific aspects relating to each typology of interviewee, and others are identical, in order to guarantee a certain comparability between different typologies.

In our analysis, we take into account just the results of interviews with EMAS adopters and no-adopters, which constitute a sub-sample of 101 observations.

The EMAS adopters were selected by random sampling (from EMAS registered private organizations population) according to the following criteria:

- representative territorial distribution;
- representative distribution according to organization's size;
- representative distribution according to the type of organization.

In order to determine the statistic relevance of the sample, a distribution of binomial probability for the population was assumed and a value for the standard error was fixed. As the variance is unknown, the most disadvantaged case was considered (i.e.: the value that maximizes the function (p), and that therefore corresponds to p=0,5) and a level of confidence equal to 95% was settled.

At the moment of the composition of the sample[9], the population was constituted by 3072 EMAS adopters, while the selected sample counts 70 private organizations.

On the other hand, the sample of EMAS not adopters is constituted by 31 organizations and was selected with the same criteria as the EMAS adopters.

At statistical level, if a sample of firms is selected using an adequate sample methods, it can be considered representative of the population of firms and therefore the conclusion obtained by the analysis can be generalized, keeping in mind the degree of error, determined by the sampling method.

[9] On 31st January 2005

The combined sample – EMAS adopters and not adopters – is used to test the Hypothesis 1, 2 and 3. While Hypothesis 4 was evaluated considering only the EMAS adopters sample (56 observations after cleaning up the missing values). The main characteristics of the sampled organizations are summarized in Table 6.

Table 6 Samples' description

		Total	EMAS adopter
Regional distribution	Baltic	14	8
	Mediterranean	35	24
	Central	39	30
	Atlantic	13	8
Organization size	Small Organizations	25	19
	Medium Organizations	35	28
	Large Organizations	41	23
Sector of activity	Manifacturing	47	36
	Other industrial secrotrs	24	13
	Service sectors	30	21

Since the data from the EVER study were collected using survey techniques, it is important to address the limitations of the survey data. Two of the main standard drawbacks, of survey data in general, are social desirability bias and lack of generalizability. The social desirability bias refers to the fact that individuals attempt to answer survey questions in ways they consider socially desirable (Darnall *et al.*, 2008a). In order to limit the potential issue associated with this kind of bias, all respondents were guaranteed anonymity and the interviewers were adequately trained to inform them to be objective. Moreover our pre-test analysis of the survey did not find any indication of social desirability bias .

Furthermore, the EVER survey was not affected by the bias due to the lack of generalizability, since it targeted industrial and service sectors in several European countries. This approach differs from typical research survey examining organizations' environmental practices, which focus on a single industry within a single country (Darnall *et al.*, 2008a).

3.2 Econometric Model

Having defined the theoretical model, we now propose the following equations as an empirical approach to test the four hypotheses of this study.

Equation N. 1

$$ENVPER = \alpha_0 + \beta_1 EMASAGE + \beta_2 ENVTARGET + \beta_3 GSCM + \beta_4 SIZE + \beta_5 SECTOR + \varepsilon_1 \qquad (1)$$

Equation N. 2

$$\begin{cases} MKTPERF = \gamma_0 + \gamma_1 ENVPERFORMANCE + \gamma_2 EMASAGE + \varepsilon_2 \\ INNOVPERF = \delta_0 + \delta_1 ENVPERFORMANCE + \delta_2 EMASAGE + \varepsilon_3 \\ RESEFF = \phi_0 + \phi_1 ENVPERFORMANCE + \phi_2 EMASAGE + \varepsilon_4 \\ INTASS = \lambda_0 + \lambda_1 ENVPERFORMANCE + \lambda_2 EMASAGE + \varepsilon_5 \end{cases} \qquad (2)$$

With regards to testing Hypotheses 1, 2 and 3, we utilize a binary probit model (Equation N. 1). At this stage, we test whether EMAS maturity and specific indicators of environmental practices increase the probability of improving environmental performance. To construct an organization's environmental performance rating (i.e. the dependent variable in equation n.1) we use the EVER survey question "*How has the environmental performance of your organisation changed in recent years?*". Although it would be ideal to use quantitative data on environmental impacts, the use of self-reported data is not uncommon in related literature (see for instance Dasgupta *et al.*, 2000; Khalid *at al.*, 2006; Henriques & Sadorsky,2006; Arimura *et al.*, 2007).

The explanatory variables for the binary probit model include different characteristics of EMS, especially regarding maturity and effectiveness. Similar to Rennings *et al.* (2006), EMAS maturity was measured considering the age of registration (EMASAGE). A binary variable measuring the ability of an organization to attain its environmental targets (ENVTARGET) was constructed using the survey question *"Does your organisation attain its targets for environmental improvement?"*. In order to evaluate the relationship between encouraging suppliers to adopt environmental measures and environmental performance improvement, a binary variable (GSCM) was created on the basis of the survey question *"Do you support your suppliers to adopt environmental measures?"*.

Moreover, other survey information such as the size of the organization and sector of activities used as a set of exogenous variables are expected to affect both environmental performance and the adoption and effectiveness of voluntary practices.

The econometric model shown by Equation N.2 is used to verify whether EMAS-registered organizations with higher environmental performance also have better competitive performance (Hypothesis 4). Given that competitive performance might be achieved by relying on several competitive factors, a multivariate regression was used to estimate the simultaneous effects of the predictors variable on the different measures of competitiveness.

The basic assumptions for utilizing a multivariate regression are that the outcome variables shall be normally distributed and at least moderately correlated. The Shapiro-Wilk test was applied to verify the normal distribution of outcome variables.

According to the abovementioned literature, we have constructed four variables to measure competitiveness: market performance (MKTPERF), innovation capability (INNOVPERF), resource efficiency (RESEFF) and intangible assets (INTASS).

For each variable, we used two questions regarding the competitive advantages perceived by the organizations registered according to EMAS. The respondents were asked to rate the level of perceived benefits on a five-point Likert scale where, 1=very low and 5=very high.

Then, as Lanoie *et al.* (2007), we derived the variables by using a linear combination of specific answers to selected questions (see Table 7 for details).

All the variables are moderately correlated and the relation is highly significant (see Table 8). The same approach used for the dependent variables is applied to measure the improvement of an organization's environmental performance (ENVPERFORMANCE).

Finally, to capture the influence of EMAS maturity on competitive performance, the variable EMASAGE is considered in the model as a set of binary variables.

The Table 9 provides descriptive statistics for the study's variables.

Table 7 Dependent and explanatory variables for competitive and environmental performance (multivariate regression model)

Variable	Questions
MKTPERF	*By participating in EMAS, has your organization obtained higher customer satisfaction?* *By participating in EMAS, has your organization obtained an increase in market share ?*
INNOVPERF	*By participating in EMAS, has your organization improved its technical innovation capability?* *By participating in EMAS, has your organization improved its capability to innovate organizational and/or managerial structure?*
RESEFF	*By participating in EMAS, has your organization experienced cost savings through the decrease in resource use, reuse or recycling?* *By participating in EMAS, has your organization experienced cost savings through waste reduction?*
INTASS	*By participating in EMAS, has your organization achieved greater motivation and participation of employees?* *By participating in EMAS, has your organization perceived an improved image and reputation?*
ENVPERFORMANCE	*How has the environmental performance of your organisation changed in recent years?* *How does the environmental performance of your organisation compare to other organisations in your sector?*

Table 8 Correlation matrix

	MKTPERF	INNOVPERF	INTPER	RESPROD
MKTPERF	1.00			
INNOVPERF	0.40*	1.00		
INTASS	0.46*	0.58*	1.00	
RESEFF	0.41*	0.61*	0.60*	1.00

* $p < 0.001$

Table 9 Descriptive statistics

Variable	Observations	Mean	Std. Dev.
1st MODEL			
ENVPERF	101	.4554455	.5004948
EMASAGE	101	3.485149	3.354441
ENVTARGET	101	.8514851	.3573832
GSCM	101	.6732673	.4713578
SMALLSIZE	101	.2475248	.4337267
MEDSIZE	101	.3465347	.4782393
LARGSIZE	101	.4059406	.4935224
MANIFACT.	101	.4653465	.5012855
OTHERIND	101	.2376238	.4277503
SERVICE	101	.2970297	.4592288
2nd MODEL			
MKTPERF	56	6.589286	2.535399
INNOVPERF	56	6.678571	2.240999
RESPROD	56	7.678571	1.820161
INTPER	56	6.589286	2.755337
ENVPERFOR	56	8.464286	1.159377
EMASAGE	56	4.5	2.879394

4. Results

The results of the model application carried out in our analysis provide some evidence for the hypotheses described above.

First of all, the model seems to support Hypothesis 1, i.e. the number of years the EMS has been adopted has a positive effect on the level of environmental performance perceived by the organisation itself. But, even if this relation is positive, we have to acknowledge that the effect of the age of the EMS is not very high (see the dF / dx value). This implies that the influence exerted in time by the EMS on the capability to improve environmental performance is counterbalanced by other factors. On one hand, organizations identify a strong stimulus towards a higher environmental performance in the EMAS main requirement to pursue the so-called "continuous improvement". Moreover, a "learning by doing" effect is detectable in the EMAS registered organisations, increasing year by year their ability to implement the EMS, to optimise the improvement opportunities and to maximise the cost-effectiveness of the money they invest in environmental improvement. On the opposite hand, some significant counter-effects hindering the capacity to positively affect environmental performance may emerge over time, as the EMS matures. Many organizations emphasised the problems of the increasing marginal cost of pollution abatement, as well as the difficulties in spotting new improvement margins and opportunities every year for their industrial sites, plants or corporate activities (IEFE Bocconi *et al.*, 2006).

Among the independent variables that are included in the model, the ability to carry out effective planning and to achieve foreseen targets seems to have the strongest impact on environmental performance. Hypothesis 2, i.e. the existence of a positive influence of target-definition and successful planning on environmental performance, is fully confirmed by the results we achieved. In this case, the intensity of the detected impact is high (see the dF / dx value) and a 95% significance is provided by the model. The most important indication emerging from this result concerns the organisations' approach in implementing their EMSs. The organisations involved in the EMAS scheme clearly showed different attitudes when considering their EMS. The two opposites being a "certificate-oriented" approach (to obtain EMAS registration and preserving it as a reputational tool) and a more "strategic" approach, aiming at using the EMS to guarantee legal compliance and gradually improving the environmental efficiency of corporate activities (IEFE Bocconi *et al.*, 2006). It is rather clear, from our results, that the more an organisation considers its EMS as an integral part of its whole management system and includes the environmental targets and programmes in the day-to-day operational planning activities, the more it is able to effectively achieve a higher environmental performance.

On the contrary, the “certificate-oriented” approach, basically aimed at guaranteeing that the EMAS requirements are fulfilled in order to obtain the registration, proved to be rather ineffective. If an organisation believes that renewing EMAS registration is enough to uphold its reputation over time, and it does not rely on real resource mobilisation and efficient planning, the effects on environmental performance will be poor.

The outcomes of the model application weakly support Hypothesis 3. Organisations that make an effort to correctly manage the environmental aspects in their supply-chain do not necessarily perform better in absolute terms. The effect of a proactive Green Supply Chain Management, as measured by the model, on environmental performance is positive and not negligible, but the low significance value shows that the relationship between the two variables is not statistically supported by our empirical evidence. This might be due to a relative immaturity in the GSCM tools available, as well as in their development and actual application by the interested companies.

Despite more than 50% of the surveyed organisations are adopting tools and methods to support the actors operating in their value-chain (mostly suppliers, but also service providers, customers and retailing partners), the interviews and case-studies carried out in the EVER study clearly show that these strategies are still lagging behind with respect to many other areas of supply-chain management, especially by industrial firms (IEFE Bocconi *et al.*, 2006).

What is virtually missing from our empirical evidence is the adoption of “front-running” supply-chain management activities which are being developed in other business areas, such as: product co-design strategies, common innovation patterns (e.g.: “learning by interacting” with the technology providers) or joint marketing campaigns, applied to environmental issues. This is a sign that the GSCM is still not very diffused among organisations and, consequently, is not able to provide effective stimuli to improve overall environmental performance, at least in a perceivable and measurable way. Such a situation might be due to the slow uptake of the so-called "indirect environmental aspects", foreseen both by EMAS and ISO 14001. It is widely recognised that these aspects are often undermined and/or not identified, assessed and managed in an effective way by the organisations adopting an EMS. Quite interestingly, the draft proposal of the new EMAS regulation (the so-called EMAS III) will strongly emphasise the need to further develop the managerial and technical issues of indirect aspects (especially those concerning the supply chain) (European Commission, 2008).

Final evidence emerging from our analysis refers to the relative importance of an organisation's size as an exogenous variable. In particular, the large size of an organisation applying an EMS proves to be a strong determinant of its good environmental performance, as perceived in the survey. This is consistent with most part of the literature on EMS-related issues, which generally identifies barriers and drawbacks for smaller companies, owing to a wide range of factors (e.g.: lack of resources, low degree of competence and knowhow, cultural gap, organisational lag, etc.). It is quite interesting to note that our analysis shows that these barriers are also preventing SMEs to achieve a better environmental performance, once they are able to implement an EMS and to eventually obtain a certification / registration.

Table 10 Results of binary probit model predicting environmental performance improvement

Dependent Variable **Environmental performance**	**Coefficient**	**dF/dx**	**Std. Err.**	**P value**
CONSTANT	-1.6531		.5397193	***
EMASAGE	.1003	.0396	.0444161	**
ENVTARGET	.8679	.3054	.4235474	**
GSCM	.5594	.2142	.3236967	*
SMALLSIZE	.3929	.1456	.3710019	
LARGSIZE	.9274	.3566	.332258	***
MANIFACT.	-.6101	-.2366	.3814459	
SERVICE	-.4903	-.1881	.5397193	

Log likelihood	-59.333511	
Correctly classified	68,32%	
Pseudo R2	0.1476	

*** $p < 0.01$ ** $p < 0.05$ * $p < 0.1$

The second step of our model application tested Hypothesis 4, i.e. that EMAS-registered organizations with higher environmental performance have better competitive performance. Some conclusions can be drawn from the results of the multivariate regression model reported in Table 11.

Only one of the equations provides statistically significant evidence for this relationship. In fact, Equation n.2 proves that EMAS organizations that are perceived as better performing from an environmental viewpoint are also able to improve their innovation capabilities as a key competitive factor. If we compare this result with the first step of our model, the reasons for this are easily understandable. Since environmental performance is positively linked to the age of the EMS and the extent of investment planning and resources, then we can argue that this can produce a higher innovative-orientation in the organization, together with a "cumulating" know-how and an increased technical ability to sustain innovation patterns. In other words, the more the organization invests in environmental innovation, the more it is capable of developing new technologies and organizational solutions, and to manage them effectively. This makes it possible to improve the competitive factors based on innovation.

The outcome of our analysis does not allow us to elaborate definite conclusions regarding the other equations. The results are too weak to identify any relation between environmental performance and any of the other variables involved such as market performance, intangible assets and resource productivity.

In particular, as emphasised by many authors (Biondi *et al*., 2000; Carnimeo *et al.* 2002), an EMAS registered organisation very seldom obtains positive feedbacks directly from the market (final consumers or intermediate customers). This does not allow to get an undisputable advantage over competitors thanks to EMAS registration. The same can be said with reference to intangible assets, both of an internal and an external nature. The benefits that can be experienced as to employee motivations, human capital or better organisational roles and responsibilities is not easily measurable and, therefore, many EMAS organisations tend to underestimate (or to ignore) them. The relationship with external stakeholders is linked to the effectiveness of EMAS as a communication tool, which emerged from the EVER study as one of the weakest point in the current Regulation (for more details see references IEFE Bocconi *et al.*, 2006).

Even if the model provides uncertain indications as to these three equations, a last interesting result must be mentioned.

Most of the studies and researches on EMAS implementation by companies pointed out that the competitive advantages of EMAS registration are perceived by adopters only in the long run (Hillary, 1999; Biondi *et al*., 2000). Moreover, some studies emphasise that there is a strong relation between the extent to which these advantages are perceived and the degree of EMS implementation (i.e.: proportional to the experience in time) (Rennings *et al.*, 2006; Darnall *et al.,* 2008). On the basis of these considerations, we implicitly tested another hypothesis in our model: the age of the EMAS-registered EMS (as an exogenous variable) can influence the way in which the organisations perceive the benefits from a competitive point of view. As it clearly emerges from Table 6, this hypothesis is falsified by the empirical evidence collected in the EVER study, since there is no explicit correlation in any of the Equations of the model. It does not seem to be a matter of time if a company perceives competitive benefits linked to their environmental performance or not.

Table 11 Results of multivariate regression model predicting competitive performance of EMAS registered organization

	Equation 1	*Equation 2*	*Equation 3*	*Equation 4*

Independent Variable	Market performance		Innovation capabilities		Intangible assets		Resource productivity	
	Coefficient	*Std. Err*	*Coefficient*	*Std. Err*	*Coefficient*	*Std. Err*	*Coefficient*	*Std. Err*
CONSTANT	.3960108**	2.663971	-.7299709	2.163735	3.565903*	1.871218	-.1891199	2.805155
ENVPERFOR	.6388674*	.3108502	.6388674***	.3108502	.4364561*	.2183465	.6087822*	.3273246
EMASAGE-2	2.29305	1.33194	2.012019 *	1.081831	1.342447	.9355774	2.718862*	1.40253
EMASAGE-3	.2192499	1.18934	.2771291	.9660079	-.2446053	.8354127	1.772241	1.252372
EMASAGE-4	.4136974	1.192238	2.460737**	.9683618	1.121615	.8374484	2.256701*	1.255424
EMASAGE-5	.9097297	1.334115	2.183173*	1.083597	1.680574*	.9371049	2.953593**	1.40482
EMASAGE-6	.5652767	1.329762	2.069071*	1.080062	-.5448439	.9340474	.7971058	1.400236
EMASAGE-7	2.10973	1.334115	2.183173*	1.083597	.2805737	.9371049	1.953593	1.40482
EMASAGE-8	2.160675	1.922084	2.369391	1.561158	2.160675	1.350104	5.123253**	2.02395
EMASAGE-9	-.4013642	1.376886	1.211378	1.118337	-.0685912	.9671483	1.866567	1.449858
EMASAGE-10	2.187516	1.62923	1.297275	1.323296	-.1606754	1.144399	3767467	1.715575
R-squared	0.2058		0.3293		0.2397		0.2543	

*** $p < 0.01$ ** $p < 0.05$ * $p < 0.1$

5. Conclusions

The EMSs, in spite of their application in many years, have not yet achieved a high degree of "maturity" in their implementation. Moreover, they are not fully integrated in those corporate management dynamics (e.g.: R&D, supply chain management, etc.) that would enable an organization to effectively exploit its operational tools and instruments. This is particularly clear with respect to "supply chain management" and its effect on an organizations' performance and on their abilities of valorizing the certification towards the market and the stakeholders.

For other aspects, the EMSs seem to be implemented in a more comprehensive and effective way by EMAS registered organizations. For instance, environmental planning capabilities are usually stronger and better "rooted" in the EMAS registered organization and, consequently, they are able to generate positive effects on environmental performance. This confirms that an actual performance improvement can be achieved only when those elements of an EMS which can be fully integrated in the management dynamics of a firm start to work effectively (Biondi *et. al.* 2000).

Another important result emerged from our study concerning the role of EMAS in improving the competitive performance of the registered organizations. Today, the effects on competitiveness is a top-priority issue for the research agenda of many institution and still a very debated issue. The European Commission, for example, has recently funded a study to focus on costs and benefits of EMAS adoption for SMEs (and on their main determinants), in order to fill the gap of evidence on this aspects[10]. From our study it emerges that, with no doubt, the implementation of an EMS according to EMAS requirements provides a powerful impulse for an organization's innovation capabilities (Rennings *et al.* 2006), but our work also clearly emphasizes that simply adopting EMAS is not a sufficient condition. The outcome of our model application shows, in fact, that only if an organization obtains a real environmental performance improvement by way of its EMS, then it can achieve better innovation capabilities. Moreover, the EMS "maturity" is not a determinant *per se* of competitive performances (even if it has a positive effect on environmental performance improvement), To this end, it is the extent to which an EMS permeates into the organizational structure that it can strongly influence competitiveness. This implies that also a "young" EMS, if well-designed and implemented (as well as adequately supported by investments), can provide considerable competitive benefits.

With reference to other competitive performances, our study shows that a positive effect of a well-implemented EMS (complying with EMAS) on resource productivity, market performance and intangible asset is not strongly supported by the statistical analysis. Our sample size is certainly a relevant constraint of the analysis, but it is not the only reason. The competitive advantages linked to EMAS as well as to ISO 14001 adoption, are still scarcely perceived by the adopters also because EMAS and ISO 14001 are not properly designed to provide them. This is particularly true for market performance and intangible assets, as corporate reputation, (we can mention, for example, the relevant constraints in the use of the EMAS logo for competitive purposes).

[10] Contract No ENV.G.2/ETU/2008/0084R; Object of the contract: Costs and benefits of EMAS registered organizations

In order to improve the use of EMAS and ISO 14001 as competitive tools, on one hand, registered organizations should strengthen their external communication within the EMS and the policy makers should support the market potentials of these certification schemes, by increasing the awareness of customers and citizens on their environmental guarantees (e.g.: through public communication campaigns). It is particularly appreciable that the draft proposal of the new EMAS III Regulation presented by the European Commission is heading in this direction.

CHAPTER 4: Determinants and effects of Green Supply Chain Management (GSCM)[11]

Abstract

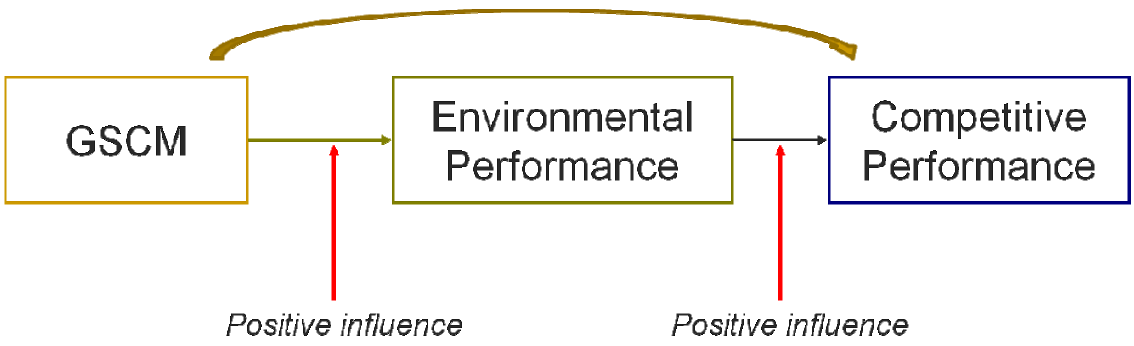
Green Supply-Chain Management (GSCM) is an increasingly widely-diffused practice among companies that are pursuing environmental excellence. The motivation for the introduction of GSCM may be ethical (e.g. reflecting the values of managers) and/or commercial (e.g. gaining a possible competitive advantage by signalling environmental concern). Drawing upon a database of over 4,000 manufacturing facilities in seven OECD countries this paper assesses the determinants and motivations for the implementation of GSCM. We find that GSCM is strongly complementary with other advanced management practices, and that it contributes to improved environmental performance. The effects on commercial performance are more ambiguous.

[11] Submitted in *Journal of Cleaner Production;* Co-authors: Fabio Iraldo, Nick Johnstone.

1. Introduction

Green Supply-Chain Management (GSCM) is an increasingly widely-diffused practice among companies that are pursuing environmental excellence. The motivation for the introduction of GSCM may be ethical (e.g. reflecting the values of managers) and/or commercial (e.g. gaining a possible competitive advantage by signalling environmental concern). Notwithstanding its growing diffusion and success, many factors are still hindering the adoption of GSCM by companies, especially SMEs. In the present article we carry out an analysis of GSCM benefits and costs, starting from the strategic drivers that encourage an organization to adopt it and then testing its effectiveness both from an environmental and economic perspective. According to the main findings in literature, we presume that GSCM is able to positively influence a company's environmental performance and, also owing to this, to effectively support its competitive strategies based on environmentally sound reputation (see Fig.3). Our work looks at the two typical actions that an organization can adopt for influencing the environmental performance of its suppliers and, as a consequence, indirectly also of its own production process or products: assessing their environmental performance and requesting that they undertake environmental measures.

Figure 3 The conceptual framework



2. Theory and hypotheses

2.1 The determinants of green supply chain management adoption at firm level

At the empirical level, several studies identified a wide range of factors that can persuade an organization to extend environmental management criteria and practices to its supply chain. This can be stimulated by customers' requests, induced by the need to guarantee a full compliance with more stringent environmental regulation, or even prompted by strategic motivations linked to the opportunity to get a competitive advantage on the market (Darnall *et al.* 2008; Nawrocka, 2008; Sharfman *et al.*, 2009).

In the literature, the determinants of GSCM adoption can be basically distinguished between: "external factors", mostly linked to stakeholders' pressure; and, "internal factors", i.e. to a specific business-led strategic process. These differ according to the source of the "stimulus" that drives the development of GSCM practices, and that encourages their diffusion through the supply-chain, and the sharing of these practices with customers and suppliers. With respect to "external factors", many authors focused, for instance, on the effects of institutional and regulatory pressure on an organization's decisions to adopt such practices (Birett, 1998; Tsoulfas & Pappis, 2008). The "institutional" pressures can encourage managers to undertake supply chain-oriented strategic actions in order to increase their external reputation, improve the influence on the supply-chain decision processes and upgrade their image on the market, while "regulatory" pressures arise from threats of noncompliance penalties and fines or from requirements to publicly disclose information concerning the organization environmental impacts (Konar & Cohen, 2008).

On the other hand, "internal factors" can be defined as those strategic motivations that can encourage managers to adopt actions that aim at designing (or rationalizing), implementing and better managing business relations in the supply chain, and that are not spurred by external stimuli, and not even necessarily pursuing external objectives (e.g.: customer satisfaction or market penetration). Examples of "internal" factors driving GSCM-oriented actions are the following:

- the engagement of inter-firm cooperation, aiming at identifying and carrying out environmental improvements, both on the input-side of the product life cycle (e.g.:

procurement, co-operation with main suppliers) and on the output-side (e.g.: organizing recycling, information on proper use for final consumers, etc). These are implemented to pursue cost-reduction and to increase efficiency (Corbett & DeCroix, 2001);

- the selection of providers who have adopted effective environmental practices (i.e. applying an environmental management system that complies with ISO 14001 requirements) can be carried out because there is an expectation that the environmental risks associated with these vendors is lessened (Sarkis, 2003).

Supply chain-oriented environmental management is therefore developed by organizations not just as an *ad-hoc* operational response to external pressures, but can be a key-element of a business strategic vision, aimed at pursuing better environmental and commercial results (most of the times in a synergetic way).

Pursuing a better “competitive performance” can have different meanings and can be done in many ways. The three most diffused strategic approaches that are able to spring and favor the adoption GSCM practices by firms are the following:

1) *“reputation-led”*: to improve the environmental performance of the whole product life-cycle, e.g. by setting up a co-operative “green” logistic system involving suppliers to reduce transport emissions, and make the customers and consumers aware of this system, can significantly contribute in maintaining or creating a positive corporate image;
2) *“efficiency-led”:* a supply chain-oriented business strategy can aim at reducing the use of raw materials per unit of product or the weight and thickness of the packaging thanks to innovative solutions, leading to cost savings and, therefore, enabling the company to supply a cost-competitive product to the market
3) *“innovation-led”:* GSCM can be also seen as the result of an innovation leader’s strategy. Those companies that are front-runners in developing product and process innovations, both from the technological and from the organizational points of view, can find in pioneristic GSCM-related practices an opportunity to strengthen their leadership and to create a gap with respect to their competitors. And vice-versa, by adopting GSCM practices, innovation leaders find new stimula for developing further innovation patters. For instance, Vachon and

Klassen (2007) found that resources were increasingly allocated towards pollution prevention when plants developed extensive strategic-level integration with suppliers, including environmental aspects linked to product development and knowledge sharing.

Even when they are not generated within one of the above-mentioned approaches, GSCM practices in some cases can be considered as an outcome of a “strategic” process. This happens when environmental “external factors” become such strong and comprehensive competitive pressures that they inevitably induce the adoption of GSCM also by followers. The wide diffusion of GSCM practices in the last years, especially in specific industrial sectors (e.g.: food and beverages, textile, chemicals, etc.) encouraged many organizations to follow the strategy of the *first-movers*. in order to compensate their competitive disadvantage compared to the early-adopters of environmental practices in coordination with their suppliers. We can define this last case as an “imitation-led” approach.

In order to better understand the dynamics that are able to originate GSCM, we focused our analysis on “strategic determinants”, i.e. we tried to isolate those cases in which GSCM practices are not just a single aspect of business strategy, or an accidental and “spot” response to an external stimulus, but they are an integral part of a strategic process, even if this choice is merely determined by a “follower” strategy.. We analyzed what strategies are more likely to generate “green” initiatives in the supply-chain.

Hypothesis 1. The factors that influence an organization to adopt GSCM practices are linked to different strategic approaches:

H1a: A corporate image strategy (reputation-led) encourages a firm to adopt GSCM practices

H1b: A cost saving strategy (efficiency-led) brings a firm to adopt GSCM practices

H1c: A products and/or process development strategy (innovation-led) induces a firm to adopt GSCM practices

H1d: A “follower” strategy forces a firm to adopt GSCM practices

2.2 Green Supply Chain Management and Environmental Management Systems

Investigating the determinants of GSCM, one cannot dismiss the possibility that there are some complementary factors which can strongly influence the attitude of a firm to develop such practices. This is especially true when a firm pursues environmental excellence by means of different tools or solutions that are strongly synergetic with (and might suggest the adoption of) GSCM practices. In particular, a shared vision among scholars and practitioners is that the "supply-chain dimension", as well as the so-called "life-cycle approach", are a necessary complement to environmental management systems. The main findings of the relevant literature emphasise that, while in the early stages of an EMS application the ISO 14001-certified or EMAS-registered companies mainly focused on "housekeeping" (i.e.: responsibilities and tasks to correctly manage site-specific environmental aspects, including procedures and operational instructions, monitoring systems and training activities), today these companies are increasingly looking "beyond the boundaries" of their production process and organisation (Klinkers, 1999) towards the whole life-cycle of their products and services and, therefore and firstly, to their supply-chain.

In recent years, a wide experience in applying EMSs showed that these "tools" can be effective not only for the adopter to manage its own environmental aspects, but also as a wider approach, particularly useful in coping with the environmental impacts originating from the supply-chain relations and from the different phases of a product life-cycle (Sharfman *et al.*, 1997). An increasing number of theoretical and empirical studies tend to prove that "expanding" an EMS by way of a life-cycle approach has a great potential for "*inter-organisational environmental management*" (Sinding, 2000), i.e. for an effective co-ordination and co-operation between companies within the supply-chain.

According to this view, EMSs are crucial when a large adopter needs to involve and support smaller companies operating in its supply-chain to achieve common environmental objectives. The relevant literature on GSCM emphasises that many difficulties arise in applying a supply-chain-oriented approach, in particular for SMEs.

The company's management control on the environmental aspects emerging from the links and interactions with the other actors of the supply-chain can be too weak, and its contractual power within these business relations not strong enough to influence the relevant decision-making (Fuller, 1999).

By focusing their EMS on supply-.chain management, some organizations in recent years have begun relying on their suppliers to improve their environmental performance and were able to create value for themselves and for their customers (Carnimeo *et al.*, 2002). For instance, IBM has designed a tool for monitoring and analyzing its products emissions throughout the life-cycle. This allows all the IBM business partners to adjust their operations and see how changes in packaging, transportation and inventory policies can affect CO_2 emissions. The aim of this tool is to quantify the trade-offs between carbon reductions and other factors affecting competitiveness (such as on-time delivery, packaging solutions, costs, etc.), share this awareness with its suppliers / customers and identify, develop and apply in co-operation with them the most sustainable and feasible solutions from both an environmental and an economic perspective.

The relationship between EMS and GSCM practices, therefore, can be complementary, with positive implications for an organization's environmental performance, because when applied together (and in a synergetic way) they offer a more comprehensive means for defining and establishing sustainable actions among networks of business partners (Darnall *et al.*, 2008).

Starting from these considerations and using a wide sample covering different industrialized countries, our work aims at demonstrating that an environmental management system is a key-determinant and a facilitator for the adoption of GSCM practices.

Hypothesis 2. EMS adopters are more likely to develop GSCM practices

2.3 GSCM as a managerial tool for improving environmental performance at firm level

The increasing diffusion of GSCM is driven mainly by the need for companies to face up significant environmental challenges that cannot be tackled by relying on their own resources (technical, managerial or even economic ones), but call for the involvement of other actors that are co-responsible of their generation. The intensive use of raw materials and natural resources, the escalating production of waste caused by consumer goods and their packaging, the impacts connected with the transportation of intermediate and consumer goods to their final markets are only some examples of environmental aspects that cannot be improved without the active participation of suppliers, retailers, clients and even final consumers (Srivastava, 2007). Therefore, the main objective of GSCM, as well as the main measure of its effectiveness, must be its capability of improving the environmental performance of those companies that adopt this approach and of their business partners.

This result has been ascertained by a large part of the literature, mostly on a case-to-.case basis. Just to mention an example, the global leader in the home furnishing, IKEA, is reported to have adopted a system to analyze and improve the environmental impact of its products, starting from the design phase. By implementing this system, IKEA asks its suppliers to undertake the commitment to apply a set of strategic and operational rules, included in the so-called "Code of Conduct IWAY", clustered in four level of performance. The aim is that 30% of suppliers achieve the fourth level of performance within the end of 2009, specifically by obtaining the FSC - Forest Stewardship Council - Certification.

Also Geffen and Rothenberg (2000) analyzed three case studies of US assembly plants and stated that strong partnerships with suppliers, supported by appropriate incentive systems, aid the adoption and development of innovative environmental technologies. In addition to this, the interaction with suppliers' staff, partnership agreements and innovation development leads to real and measurable improvements in environmental performance, maintaining production quality and cost goals.

Furthermore, in a case-study focused on the paper industry, Iraldo and Frey (2007) demonstrated that improvement in environmental performance in the supply chain provided by an intensive inter-firm relation can be strongly facilitated by firms' proximity. There are further anecdotal evidences concerning the effectiveness of GSCM in improving environmental performance, while very few studies analyzed this relation by using quantitative approaches based on surveys. Among these, Zhu and Sarkis (2004), by using analysing survey data from 186 respondents on GSCM practices in Chinese manufacturing enterprises, found that having higher level of adoption of GSCM practices (e.g.: environmental audit for suppliers' internal management, environmental requirements for purchased items, ISO 14001 certification, cooperation with suppliers and customers for environmental objectives) leads to better environmental performance. Moreover, a recent study carried out by Iraldo *et al*. (2009), based on a sample of 100 interviewed organizations, found evidence of the effect of a proactive GSCM on environmental performance.

Our analysis aims at providing a further contribution to the scarce empirical evidence that is currently available in literature on positive relations between supporting suppliers in adopting environmental measures (i.e.: an important facet of GSCM) and environmental performance improvement.

Hypothesis 3. The organizations supporting their suppliers to adopt environmental measures are able to obtain better environmental performance improvement

2.4 GSCM as a managerial tool for improving competitive performance at firm level

Economic benefits as "side-effects" of environmental improvement represent the most motivating driver for companies to initiate more sustainable production patterns. It has been argued that success in addressing environmental issues may provide new opportunities for competition and innovative ways to add value to core-business activities (Hansmann & Kroger, 2000).

In literature, the few empirical studies addressing the relation between environmental performance and competitiveness focused, almost exclusively, on the economic performance at the firm level. Evidence is not clear and univocal on this issue: some studies found a weak or a statistically non-significant relation between economic and environmental performance (Jaggi & Freedman, 1992; Hamilton, 1995), while other more recent studies achieved the opposite conclusion (Iraldo *et al.*, 2009).

On the one hand, Levy (1995), using data from several sources, emphasized that firms with more significant reductions in toxic emissions tended to have poorer financial performance - measured as “return on sales” and “return on equity and sales” -, although the relationship was not statistically significant. On the other hand, there is evidence to suggest that good environmental performance can help enterprises improve their commercial performance (Hart & Ahuja, 1996; Klassen & McLaughlin, 1996). For instance Al-Tuwaijiri *et al.* (2004) demonstrate, by a simultaneous equation model, that good environmental performance is significantly associated with good commercial performance. Focusing on a particular environmental practice such as GSCM, many authors acknowledge that an effective supply chain- oriented management, not only generates environmental benefits, but significant business benefits as well.

Dodgson (2000) and Dyer and Singh (1998) argue that inter-firm relations provide formal and informal mechanisms that promote trust, reduce risk and in turn increase innovation and profitability. Some of the key-elements of GSCM, such as involvement, analysis and control systems along the supply chain, based on environmental criteria, can reduce risks of delivering interruptions or delays resulting from a critical supplier’s compliance problem (Lipman, 1999). The adoption of GSCM practice can also protect the company’s reputation from unlawful practices carried out by suppliers. Furthermore, specific procurement practices based on life-cycle costing can stimulate suppliers to develop environmental innovations, decreasing the operation costs and achieving significant input savings (Carnimeo *et al.*, 2002).

Beyond reducing risks and costs, GSCM practices can also provide strategic and competitive benefits: improvement of the brand’s image, better relations with institutional stakeholders, increase of personnel motivation are possible effects of GSCM adoption described by the relevant literature.

More specifically, the relation between GSCM and competitiveness was investigated by very few empirical studies, that either generally analyzed the effects of a wider range of environmental management practices (including GSCM), or focused on limited geographical areas.

For instance, Welford (1995) found that environmental protection activities such as GSCM are increasingly embedded in business operations and, thus, bring some benefits for firms as an improvement in reputation. In addition, Molina-Azorın *et al.* (2009) indicated that proactive environmental management such as GSCM has a positive relationship with an organization's performance on the market.

Those empirical studies concentrating on the competitive effects of GSCM adoption, mainly focused on the South-East Asia Region where these practices seem to be more diffused. For instance, the already cited work of Zhu and Sarkis (2004), relying on 186 respondents on GSCM practice in Chinese manufacturing enterprises, proves that the enterprises developing more GSCM practices have better competitive performance, Finally, the analysis carried out by Rao and Holt (2005) identified that "greening" the different phases of the supply chain leads to a more integrated and co-operative supply-chain, which ultimately produces better competitive capabilities.

Our study aims at overcoming the limits of the existing empirical studies, by analysing in-depth the competitive effects on business performance of two particular GSCM practices, within the OECD area.

Hypothesis 4. GSCM adopters have better business and competitive performance

3. Empirical analysis

3.1 Data description

To test our hypotheses we used data collected by means of a postal survey developed by the Organization for Economic Co-Operation and Development (OECD) Environment Directorate and university researchers. The survey was implemented in seven OECD countries (Canada, France, Germany, Hungary, Japan, Norway and the United States) at the facility level in the 2003, by means of a standard questionnaire (see www.oecd.org/env/cpe/firms for a discussion of sampling procedure and survey protocol).

The questionnaire is composed of approximately 40 questions distributed in six sections: the first section focuses on the management systems and tool adopted in the facility; the second and third sections investigate the adoption of environmental practices, the motivations of their adoption and the level of innovation and achieved performance; the fourth section aims at assessing the effect of environmental policy stringency on firm's decisions; the last two sections are aimed at collecting information on the characteristics of facility and firm.

The data covers facilities in all manufacturing sectors and not only those in the more polluting sectors. The diversity in countries and sectors sampled implies a greater variation across policy frameworks, technological opportunities, and other factors that allow for the generation of more reliable estimates of different potential determinants and effects of GSCM practices.

The questionnaires were sent to CEOs or environmental managers in manufacturing facilities having at least 50 employees. Response rates range from approximately 9% to 35%, with a weighted mean of almost 25% (see Table 12). With respect to previous industrial surveys undertaken in the environmental area, this result is quite satisfactory for a postal survey. For instance, in a review of 183 studies based on business surveys published in academic journals Paxson (1992) reports an average response rate of 21%.

Table 12 Response Rate by Country

	Response Rate
Canada	25.0%
France	9.3%
Germany	18.0%
Hungary	30.5%
Japan	31.5%
Norway	34.7%
United States	12.1%
Total	24.7%

A total of 4188 facility managers were interviewed by the survey. More than half sample consisted of medium enterprises (about 62%), the 32% were large enterprises, while just the 6% were small enterprises (see Figure 4 for details). Figure 5 shows the distribution of interviews between the 7 countries involved in the survey.

Figure 4 Organizations' dimension

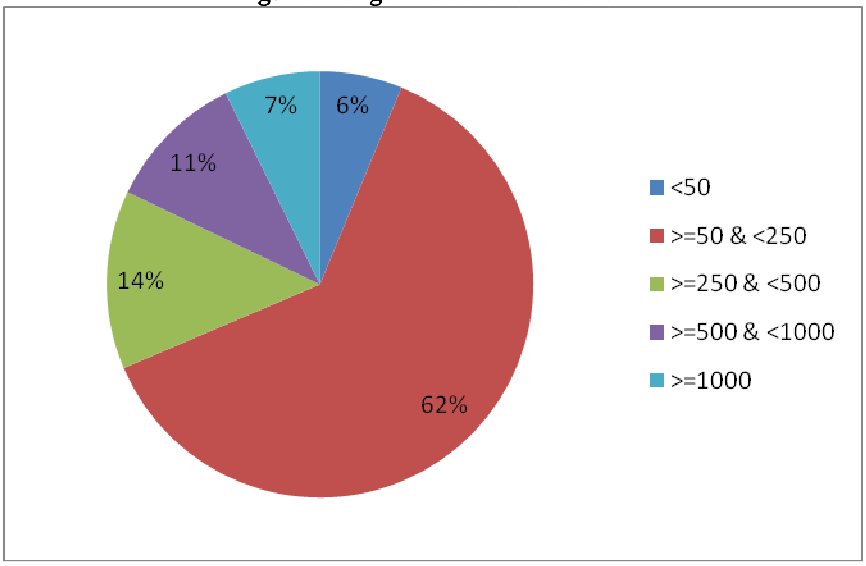
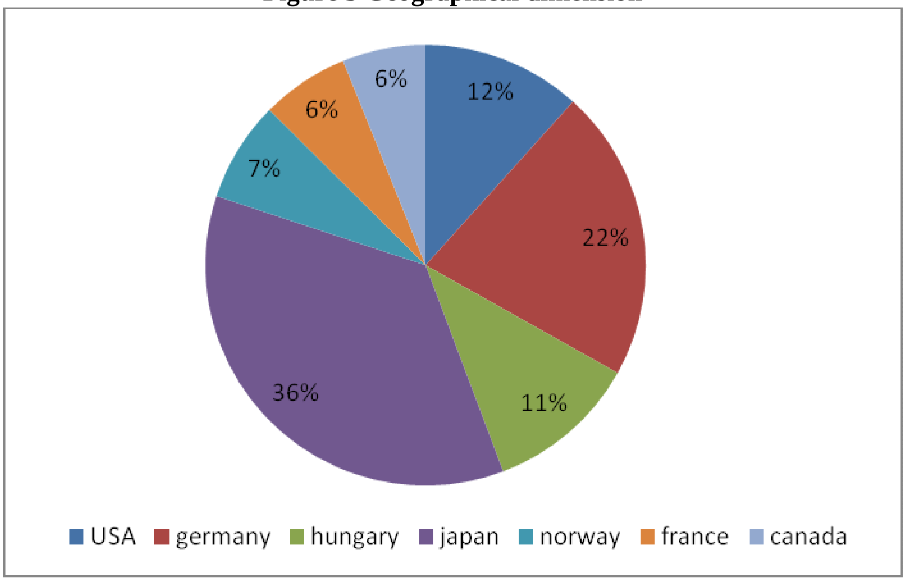


Figure 5 Geographical dimension



Since the data were collected using postal survey techniques, it is important to address their possible limitations. Two of the main standard drawbacks of survey data in general, are social desirability bias and lack of generalizability The social desirability bias refers to the fact that individuals attempt to answer survey questions in ways that they consider socially desirable (Darnall *at al.*, 2008). In order to limit the potential issue associated with this kind of bias, all respondents were guaranteed anonimity. Moreover our pre-test analysis of the survey did not find any indication of social desirability bias.

Furthermore, the survey is not affected by the bias due to the lack of generalizability, since it did not target only one sector in a country but several industrial sectors in multiple countries. OECD examined the general distribution of respondents (by considering industry representation and facility size) relative to the distribution of facilities in the broader population. It found no statistically significant differences (Johnstone et al., 2006).

3.2 Econometric Model

Having defined the theoretical model, we now propose the following equations as an empirical approach to the test four hypotheses of this study.

Equation N. 1

$$\begin{cases} ASSSUPL = \gamma_0 + \gamma_1 IMAGE + \gamma_2 COSTSAV + \gamma_3 PROD\_DEV + \gamma_4 IMITATION \\ + \gamma_5 EMS + \gamma_6 CONTROL + \varepsilon_1 \\ REGSUPL = \delta_0 + \delta_1 IMAGE + \delta_2 COSTSAV + \delta_3 PROD\_DEV + \delta_4 IMITATION \\ + \delta_5 EMS + \delta_6 CONTROL + \varepsilon_2 \end{cases}$$

(1)

Equation N. 2

$$\begin{cases} USERES = \phi_0 + \phi_1 ASSSUPL + \phi_2 REGSUPL + \phi_3 CONTROL + \varepsilon_3 \\ WSTPROD = \lambda_0 + \lambda_1 ASSSUPL + \lambda_2 REGSUPL + \lambda_3 CONTROL + \varepsilon_4 \\ WSTWATER = \omega_0 + \omega_1 ASSSUPL + \omega_2 REGSUPL + \omega_3 CONTROL + \varepsilon_5 \end{cases}$$

(2)

Equation N. 3

$$BUSSPERF = \alpha_0 + \beta_1 ASSSUPL + \beta_2 REGSUPL + \beta_3 CONTROL + \varepsilon_6$$

(3)

Explanatory variables

In order to test Hypotheses 1 and 2, we utilized a binary probit model (Equation N. 1). At this stage, we tested what business strategies increase the probability of adopting a specific GSCM practice. Furthermore, we tested if the adoption of an EMS can encourage an organization to analyze the environmental performance of its suppliers.

To define the dependent variables of the first model we used the two following survey questions: "*Does your facility regularly assess he environmental performance of own suppliers?*" and "*does regularly require suppliers to undertake environmental measures?*". The use of these actions as a proxy for measuring, in more general terms, the GSCM practices adoption by companies is well supported in the literature (see Zhu & Sarkis, 2004).

A set of binary variables was created to measure the strategic motivations of companies to adopt GSCM initiatives. Focusing on the strategic vision of a company on environmental excellence as a competitive factor (and not only specifically on GSCM adoption), we construct the "determinants" variables using the answers to the following question: *How important do you consider the following motivations to have been with respect to the environmental practices of your facility?"*. Among the several options included in the surveys we used those that are better able to reflect the business strategy: improving corporate profile/image (IMAGE), saving costs (COST_SAV) developing new products/technologies (PROD_ DEV), imitating competitors (IMITATION). These variables correspond to the four approaches to GSCM defined above ("reputation", "efficiency", "innovation" and "imitation"-led approaches).

Moreover, we constructed a binary variable to measure the adoption of structured environmental management systems, including formal EMSs such as EMAS and ISO 14001 and informal ones (EMS). The econometric model set out in Equation N.2 was used to verify whether the adoption of GSCM practices is really effective and, therefore it is able to improve the environmental performance of the adopters (Hypothesis 3).

According to Arimura *et. al* (2008), in order to define facilities' environmental performance measures (i.e., the dependent variables in equation n.2), we used the survey question, "*Has your facility experienced a change in the environmental impacts per unit of output in the last three years with respect to the following (impact)*?" Using alternatives provided in the question, we constructed an ordered response variable (significant decrease, decrease, no change, increase, significant increase) for the three environmental impacts we studied: natural resource use (i.e., energy and water), solid waste generation and wastewater emission.

Although it would be ideal to use quantitative data on environmental impacts, the use of self-reported data is not uncommon in the literature (see for instance Dasgupta *et al.* 2000; Khalid *et al.*, 2004; Henriques & Sadorsky, 2006).

With regard to the Equation n.3, we used an ordered probit model for testing the influence of GSCM adoption on companies' business performance and competitiveness. In particular, we identified "profitability" as an effective proxy for the wider concept of competitiveness, measured by using OECD data relating to the question addressed to environmental managers that investigates if their company's profit had changed over the past three years. Respondents replied using a five-point scale, indicating whether revenue was "so low as to produce large losses," "insufficient to cover our costs," "at break even," "sufficient to make a small profit," or "well in excess of costs."

Table 13 provides descriptive statistics for the study variables.

Table 13 Descriptive statistics

	Mean	Std.Dev.	Minimum	Maximum	NumCases
ASSSUPL	0,428	0,495	0	1	4033
REGSUPL	0,364	0,481	0	1	4007
IMAGE	2,430	0.607	1	3	3943
COSTSAV	2,384	0,623	1	3	3913
PROD_DEV	2,039	0,725	1	3	3472
IMITATION	1,694	0,694	1	3	2167
EMS	0,388	0,487	0	1	4002
USERES	2,481	0,761	1	5	3619

WSTPROD	2.432	0,764	1	5	3665
WSTWATER	2,541	0,729	1	5	3283
BUSSPERF	3,460	0,989	1	5	4017

Exogenous Variables

Using information in the survey, we also constructed a set of exogenous variables that were expected to affect the GSCM adoption and/or environmental and competitive performance. These variables include some specific firm characteristics such as the number of employees in the facility (*FACEMPL*), whether the firm to which the facility belongs is listed or not (*FRMQUOT*) and the presence of an environmental department within the facility (*FRMDEPT*), which reflects a structured management approach to environmental issues.

The position along the supply chain might also influence the adoption of environmental practices such as GSCM. A facility is more likely to adopt some actions on its own suppliers if its primary customers (such as other manufacturing firms) request some environmental requirements or if the final consumers show a high environmental sensitiveness in their preferences. By taking “other manufacturing firms” as a reference case of primary customers, we constructed three dummy variables; PRIMECUST1, PRIMECUST2, and PRIMECUST3 which take the value one if the primary customers are wholesalers, households, and other facilities within the same firm, respectively.

Another external factor is certainly the spatial scope of market where the firm competes (MRKTSCP). At the global level the competition can be more stringent and the need to acquire a competitive edge is higher than in a local market, stimulating companies to look for new opportunities, such as environmental excellence and in particular GSCM, that might provide advantages from differentiation.

Finally, in order to capture the effect of external context and its possible implications on the company decision-making (and on its performance), we also consider the facility’s geographical location and the sector of operation.

4. Results and discussion

The results of the model application carried out in our analysis provided some evidence relating to the Hypotheses described above.

1. The determinants of GSCM adoption by companies and the relevance of EMSs

Most of the determinants that have been identified by the literature on GSCM are confirmed by our model. First of all, the approach that we defined as “reputation-led” seems to be the most effective in stimulating the adoption of the two analysed GSCM practices. On one hand, companies that are pursuing a better image on the market, are often confronted with the request by different clients (intermediate customers, large retailers and consumers) that the product/service they offer is “environmentally friendlier” than the alternatives in all the phases of its life-cycle. This implies the producer’s capability to provide guarantees concerning not only its own activities but also its network of business relations. A producer cannot achieve this objective without involving, or at least trying to keep under control, its partner-suppliers.

On the other hand, in many cases a company wishes to improve its reputation firstly within the circle of its business partners. Especially for a small producer that co-operates in a network of suppliers to a large company (a very diffused typology is the supply-chain of a retailer or a big assembler of components, such as in the automotive industry), the image and reputation perceived by the other suppliers operating in the same network is of paramount importance. Its competitiveness can depend, for instance, on the ability to keep up with the peace of the environmental innovations adopted by the other suppliers of the network, or to actively participate in environmental common programmes concerning the whole supply-chain (e.g.: reverse logistic, waste-packaging recovery, design for disassembling, etc.). Therefore, it is vital for this kinds of companies to learn to develop GSCM practices in order to gain a reputation in the eye of their (often larger) business partners.

These dynamics also explain why the “imitation-led” approach to prompt GSCM is very significant, according to our findings. The stimulus for a company to initiate such practices often comes from observing the strategies and the competitive “behaviour” of both its partners and competitors. Especially if a company chooses to be a “follower” in its sector, it almost inevitably decides to adopt innovative practices only when they are tested and its effectiveness is experimented by a leader before. This happens in most cases with environmental innovations, the outcome of which is very uncertain, compared to an initial considerable investment. These “laggards” are also favoured by the fact that, when at a later stage they decide to start a co-operation with their partners in the supply-chain on environmental issues, they find many actors that are ready to collaborate, since most likely they were already involved before by the “first movers” and they benefitted from a “learning-by-doing” phase.

The results of our analysis also confirm that the “innovation-led” approach strongly influences GSCM practices adoption. This is a quite reasonable effect of the specificities concerning the environmental innovation process. Many studies on this issue emphasised that innovation dynamics in the environmental sector are characterised by a strong need for a “networking approach”. This olds true both for technological (Biondi *et al.* 2000) and organisational “green” innovation (Iraldo & Frey, 2007). A company, especially if it is an SME, has to rely on the possibility to share resources with other actors in the supply-chain in order to sustain the “sunk costs” of some crucial phases of the innovation process (e.g.: market intelligence, R&D, process engineering, etc.) and the financial resource flow needed for its implementation and maintenance. Beyond the cost-related issues, the “burden sharing” between companies (especially SMEs) operating in the same supply-chain is often the only way to overcome the lack of know-how, technical skills and information sources that are essential to develop the environmental innovation. This is the reason why innovation-oriented companies are keener to adopt GSCM strategies.

The “efficiency-led” approach to GSCM is the only hypothesis not confirmed in the model. The objective of cutting costs or saving resources does not seem to be a determinant for this kind of “green” practices. This is very much consistent with the discussion proposed here above. First of all, the adoption of environmentally-friendlier interactions with the supply-chain implies a considerable initial investment by the “catalyst” company (i.e.: the company that starts the co-operation and promotes GSCM), both in terms of customer- and supplier- relationship management and in terms of operational costs to carry out the proposed initiatives (e.g.: a reverse-logistic system, the use of new materials as "greener substitutes", etc.). These costs often represent a barrier for companies to behave as catalyst, because the "payback" of GSCM practices (as all the other environmental management practices) is yielded only in the long run.

The findings of our work strongly support Hypothesis n. 2: there is a statistically very significant relation between EMSs and GSCM adoption and, analyzing the marginal effect, we can state that with no doubt the EMS adoption is the most incident factor for GSCM. Developing GSCM practices within the context of an EMS proves to be particularly effective. By extending the management system to the relations with small suppliers or subcontractors (or even by supporting these actors in developing their own EMS and in co-ordinating with the adopter's one), for instance, the barriers and drawbacks for a supply-chain management, emphasised above, can be removed.

The synergies and mutual benefits between supply-chain management and EMSs is even more pronounced when it comes to implementing a structured management system according to ISO 14001 and EMAS. These third-party certification schemes stress the fact that, in order to be certified or registered, an organization has to demonstrate it correctly manages and continuously improves not only the "direct" environmental aspects (connected to the activities under its full management control), but also the so-called "indirect" ones (Handfield *et al.*, 2002).

Our work strongly supports the idea that an EMS can be used as an "engine" to start up and boost the development of GSCM practices.

Table 14 Results of binary probit models predicting GSCM adoption

Dependent Variable	Assess suppliers' environmental performance			Require suppliers to undertake environmental measures		
	Coefficient	dF/dx	Z	Coefficient	dF/dx	z
CONSTANT	-2.643631		-10.31***	-2.460871		-9.41***
IMAGE	.2782254	.110	4.27***	.2876007	.106	4.24***
COST_SAVING	.0106531	.004	0.18	-.0392304	-.014	-0.65
PDT_DEVELOP	.1740259	.069	3.31***	.2330522	.086	4.34***
IMITATION	.1581454	.063	2.92***	.1067157	.039	1.97**
EMS	.733767	.286	9.69***	.5806438	.218	7.69***
EMPL	.0001082	.000	1.96*	.0001252	.001	2.29**
FRMQUOT	1339559	.053	1.50	.1579657	.059	1.77*
FRMEDPT	.2108082	.083	2.60***	.1640358	.060	2.00**
PRIMCUST_2	.0057982	.002	0.07	.0913004	.034	1.15

PRIMCUST_3	-.0285062	-.011	-0.21	- .0155529	.006	0.12
PRIMCUST_4	.0597996	.024	0.37	.0770148	.029	0.47
MKTCONC_2	.148171	.059	1.75*	.2914954	.109	3.34***
MKTCONC_3	.3016655	.120	3.43***	.288876	.109	3.20***
USA	-.0027758	-.001	-0.02	-.2066409	-.074	-1.48
HUNGARY	.6820586	.265	4.68***	.4296845	.165	2.98***
GERMANY	.3659147	.145	2.77***	-.2240597	.099	1.99**
NORWAY	.8309607	.316	5.71***	-.2240597	-.080	-1.49
CANADA	.1525581	-.060	-1.00	-.5169932	-.172	-3.32***
Textile, apparel and leather sector	.3514117	.139	1.94*	.1856968	.070	1.01
Wood and furniture sector	.4466544	.176	2.70***	.3078944	.118	1.80*
Paper and publishing sector	.5019121	.197	3.10***	.1342886	.051	0.80
Refined petroleum, chemical and plastic products sector	.3574832	.142	2.51**	.2362976	.089	1.62
Non-metallic mineral products sector	-.012234	-.005	-0.06	.1679852	.064	0.86
Basic and fabricated metals sector	.3098896	.123	2.20**	.2235845	.084	1.55
Machinery and equipment sector	.3161104	.125	2.31**	-.0600002	-.022	-0.42
Transport sector	.0665653	.026	0.38	.4164557	.161	2.36**
Recycling	.3046741	.121	1.07	.2268221	.087	0.80
Log likelihood	-969.55879			-938.36224		
Correctly classified	68,90%			71,32%		
Pseudo R2	.1594			0.1394		

2. GSCM as a managerial tool for improving environmental performance at firm level

The results of the proposed model strongly supports Hypothesis n. 3, showing that the two GSCM actions considered have a strong effect in reducing the impact of the most common environmental aspects of an organization. Making specific requests to suppliers concerning the need to assure a given performance can enable a company to better manage its own environmental aspects. This is no surprise, if one considers that in most cases the way in which a company impacts the environment depends on productive choices and managerial modalities that are strongly influenced by suppliers.

Intensive use of natural resources is strongly related to the environmental performance of the suppliers' products and production processes. The electricity employed as a primary production input has different environmental impacts according to the means by which it is generated by the supplier power plants. If a company chooses (as a part of its GSCM strategy) to buy electricity from a "renewables-oriented" provider, its use of resources drastically decreases. The same can be said, for example, if a company selects its suppliers of copy-paper or corrugated board for packaging according to environmental criteria and sets the requirement of 100% recycled material as an hurdle to entering its vendor-lists. When these kinds of requests by the GSCM adopter are standardized in a supply contract, the effect on environmental performance can be even more significant. As one could expect, waste production is the case in which this factor proves to be more effective (see Table 15). It is common practice among companies to manage waste-related issues by contracting service-providers and by including requirements on waste production in the contracts defined with subcontractors operating on-site. This enables the company to exert a direct pressure and influence on the different suppliers and, therefore, to obtain positive results on the quantity (and quality) of waste produced.

On the other hand, setting requirements and imposing rules to suppliers can be less effective if they are not accompanied by the monitoring and assessment of their performance. This is the reason why the second variable considered in our model (ASSUPL) yields approximately the same results of REQSUPL. There are many different ways in which a company can undertake an assessment of its suppliers. The first (and most trivial one) is a direct consequence of the abovementioned practices: many companies carry out a preliminary check on suppliers' environmental performance in order to decide if they can be qualified and included in its vendor-list. This assessment is rather "weak" as it is often implemented only on a "documental" basis and does not foresee on-site visits and direct inspections. A more incisive approach is to ask suppliers to periodically undergo an environmental audit carried out by the GSCM adopter itself or by a second-party auditor (e.g.: a consultancy firm hired to perform this task). This approach is particularly effective, for instance, to check the compliance of the provider's operations to environmental criteria relating to the supplied intermediate products (e.g. the use of receipts and the application of consistent procedures and instructions), such as the chemicals used as auxiliaries in the water purification plants. This explains why, in our model, ASSUPL produces a significant effect also on the third dependent variable considered (WSTWATER).

Table 15 Results of ordered probit models predicting environmental performance improvement

Dependent Variable	Use of natural resources		Waste production		Wastewater effluent	
	Coefficient	Z	Coefficient	Z	Coefficient	Z
ASSSUPL	-.1693152	-4.87***	-.1305837	-2.99***	-.1452298	-3.03***
REQSUPL	-.218369	-3.87***	-.3040862	-6.80***	-.1473254	-3.14***
EMPL	-.0000582	-2.74***	-.0001136	-4.61***	-.0000888	-3.81***
PRIMCUST_2	.0104361	1.11	-.0247384	-0.54	-.0171586	-0.35
PRIMCUST_3	.0343373	0.47	-.0773613	-1.06	.0115184	0.15
PRIMCUST_4	-.1964745	2.04**	-.1637287	-1.69	-.0712367	-0.68
USA	-.1359422	-1.49	-.0696987	-0.76	.1953857	2.01**
HUNGARY	-.2668473	-3.11***	.0909424	1.98**	.4374788	4.37***
GERMANY	-.2375469	-2.50**	.1879604	1.05	.2798683	3.06***
JAPAN	-.0416307	-0.50	.0604547	0.73	.5258139	5.98***
NORWAY	-.168913	-1.63	-.123002	-1.19	.3066083	2.74***
FRANCE	-.3234288	-3.00***	.2103308	1.97**	.1211085	1.04
Textile, apparel and leather sector	-.0060695	-0.06	-.143243	-1.34	-.0263082	-0.23
Wood and furniture sector	-.0278303	-0.27	-.3415228	-3.36***	.0392327	0.35
Paper and publishing sector	-.0531662	-0.58	-.2281161	-2.47**	-.2077221	-2.16**
Refined petroleum, chemical and plastic products sector	-.0310184	-0.40	-.1785974	-2.28**	-.0122565	-0.15
Non-metallic mineral products sector	.0482629	0.43	-.1566236	-1.39	-.1049704	-0.91
Basic and fabricated metals sector	.0030841	0.04	-.104935	-1.36	.1246226	1.57
Machinery and equipment sector	.0469973	0.64	-.1507205	-2.03**	.0158013	0.20
Transport sector	.0798264	0.83	-.1894684	-1.97**	-.0148538	-0.15
Recycling	.1834007	1.11	-.2151554	-1.35	.0298226	0.17

3. GSCM as a managerial tool for improving competitive performance at firm level

The last hypothesis to be tested by our model concerned the probability that GSCM practices affect the profitability of a firm, taken as a proxy for the more general concept of competitiveness. The results of our model identified a statistical relation between both the assessment of and setting requirements for suppliers and possible effects on profits, but this relation is not strongly supported (as signaled by the Z value). Reasons for this can be numerous and of a different nature.

First of all, we have to consider that the concept of profitability is one of the stricter ways to measure the ultimate outcome of a competitive strategy. Many positive effects of the environmental business strategies are able to affect other and more "intangible" competitive assets, not necessarily resulting in increased profitability. As emphasized above, most of the studies in literature tend to associate positive competitive attributes to GSCM in terms of image and reputation (which is also one of the motives that induces GSCM adoption), but these attributes do not necessarily translate into an increase in profit. Another advantage that GSCM can produce in terms of capability to compete by the adopters is the ability to continuously innovate products and processes, thanks to the tight co-operation with other actors of the supply-chain. This ability gives the GSCM adopter better chances of timely responding to market expectations concerning environmentally sound products, anticipating the evolution of consumer preferences towards sustainability, better satisfying intermediate customers interested in the environmental performance of the supplied products and services, etc… but does not immediately yield profit. Also in this case, it is difficult to capture the competitive benefits in terms of profitability especially in the short-medium run, when the company has to invest money and time (while the return on this investment is expected to emerge in the long run).

Secondly, we have to acknowledge that environmental excellence (as reflected in the choice of adopting GSCM practices) does not necessarily produce a proportioned payback on the market. This is especially true if we focus on sectors producing consumer goods: in these cases, profitability is strictly linked to the market response for "greener products", that is still weak in many countries, and to the possibility of applying a significant mark-up on production costs (which include the supply-chain management sunk costs and investments, emphasized above).

Last but not least, a problem in using "profitability" as an estimate for the whole concept of competitiveness is due to the fact that this variable is strongly influence by financial aspects. This is a strong limitation of the model, because this particular way of measuring competitiveness by its ultimate outcome (besides not being able to fully capture all its facets) can be influenced by contingent “speculative bubbles” or crises of the financial markets. A confirmation of this can be found in our model by considering the very high Z value for the FRMQUOT dummy variable, indicating if the company (to which the sampled facility belongs) is listed on the stock market.

Table 16 Results of ordered probit models predicting business performance improvement

Dependent Variable: Business Performance	Model 1		Model 2	
	Coefficient	Z	Coefficient	Z
ASSSUPL	.0884696	2.46**		
REQSUPL			.0705855	1.90*
EMPL	.0000629	2.93**	.000062	2.89**
FRMQUOT	.2458692	5.04***	.249693	5.09***
PRIMCUST_2	.1288465	2.98**	.1215465	2.80**
PRIMCUST_3	.0622262	0.93	. 0564187	0.84
PRIMCUST_4	-.0186896	-0.21	-.0137928	-0.15
Textile, apparel and leather sector	-.3686574	-3.84***	-.3637219	-3.78***
Wood and furniture sector	-.14864	-1.56	-.1642878	-1.72*
Paper and publishing sector	.1647071	-1.93*	-.1616702	-1.89*
Refined petroleum, chemical and plastic products sector	.1024422	1.37	.0940245	1.25
Non-metallic mineral products sector	.0004854	0.00	-.0276496	-0.25
Basic and fabricated metals sector	-.1186417	-1.65 *	-.1190874	-1.65
Machinery and equipment sector	-.2154836	-3.08 **	-.2275135	-3.24**
Transport sector	-.0217265	-0.24	-.0399028	-0.24
Recycling	-.0340339	-0.24	.0086677	-0.24

5. Conclusions

The analysis of the determinants and effects of GSCM proposed in our work provides some useful indications to improve the adoption and diffusion of such practice. First of all, our findings confirm the main impulses that can effectively motivate a company to approach and develop GSCM. On one hand, they are naturally sparkled by a leadership-oriented strategy in environmental management, when a “front-runner” company needs to go beyond the boundaries of its facility (or production site) in order to carry out effective innovations or to build a stronger image for itself or its products/services. In these cases, the company needs to rely on the relations and co-operative opportunities offered by its supply-chain, in order to strengthen the credibility and effectiveness of its actions. On the other hand, GSCM is frequently adopted by “followers” as an inevitable strategic response to stimula coming from customers and consumers, or to pressures deriving from the other more proactive actors of a supply-network, that already decided to start up a GSCM initiative.

Basing on our findings, it appears that “cost-efficiency” is a very weak driver for GSCM. This is not a lever for developing this kind of environmental management practices because, especially in the “start up” phase, the investments and the “sunk costs” largely prevail, especially for the first movers.

The most interesting result of our model concerns the role of EMSs as a “nest” in which GSCM can easily originate and more effectively grow. The key to the development of GSCM practice, according to our findings, seems to be that of promoting the adoption of EMSs, also through the diffusion of the connected certifications schemes, in order to facilitate and support their gradual extensions towards the supply-chain activities. GSCM reveals all its power and effectiveness when the relations with the partners operating in the supply-chain are progressively included as an integral part of the EMS and are managed by means of the foreseen tools (i.e.: the components of the “plan-do-check and act” approach).

Another confirmation emerges from our findings, with respect to the capacity of GSCM to produce environmental improvement. The most common environmental impacts of industrial companies can (and are) ameliorated by making suppliers and customers actively participate in the programs and actions that a company sets to this aim. We can therefore deduct that the more a company is able to involve its business partners in the development of co-operative environmental plans, the more it is able to achieve the expected results and to improve its performance.

A final result of our work pertains the relationship between GSCM (and environmental management practices at large) and competitiveness. In this case, the findings are much less positive than expected. Not only GSCM is a rather “expensive” approach to be implemented by a company, but it also seems incapable of yielding profits, at least in the short-medium run. Even if this result does not mean that GSCM cannot support competitiveness (since there are other ways to do this, that we did not measure), a final and crucial indication stemming from our work is the need to work on the "market-response" for initiatives like GSCM (and for environmental excellence in more general terms), in such a way to foster the profitability of these strategies and to stimulate companies to increasingly adopt them.

CHAPTER 5: Summary and Conclusion

1. Introduction and scope

The broader discussion on how the economic development can be consistent with ecosystem *carrying capacity* and social equity principles date back to the 60' and 70' years, when the environmental topic raises relevancy. It is the period when the first environmental association were born - World Wildlife Fund (1961), Friends of earth (1969), Greenpeace (1971) – and the first environmental protection regulations were adopted.

From these debates and from the increased awareness about a new development system, the concept of sustainable development raised and its fundamental principles were presented in the "Our common future" report of the "World Commission on Environment and Development", in 1987.

This concept has given a propulsive push to public policies and business strategy "to correct the path" of economic development in many developed country. It implied a re-orientation of political objectives in order to realize a new consumption and production model, able to combine development, economic growth with environmental protection, safety and social equilibrium. This process is matured in the wake of Bruntland Commission, through several significant steps (e.g. Rio Earth Summit in 1992), and has involved the main institutions, social actors and the business in many countries.

In particular, with the development of this social and economic framework, the role of firms has changed: from simple target of public policies to an active role as "partner" of sustainable policies. Several practices and tools have been introduced to reduce their environmental impacts: environmental management systems, supply chain initiatives, cleaner production systems etc.

In the recent years, furthermore, the environmental policies of more developed countries have shown to understand this challenge. The approach of policy makers has radically changed: beside the typical policies based on the command and control approach, new policy instruments were designed in order to satisfy the complexity of requests and interests, the ambitious objectives and the needs, and to address the stakeholders' inhomogeneous strategies towards these objectives.

Some specific results have been achieved, but the path is still long and insidious. In the last years, the concept of green economy[12] has emerged in a gushing way. But it is just a fashionable dress covering an old issue: to combine competitiveness with the environmental protection principles is one of the several challenges that we have to pursue to achieve effectively a sustainable development.

The relationship between competitiveness and environment has been deeply investigated by researchers and practitioners. We can identify three ambits of analysis. First, the researchers has examined the relationship between environmental regulations and competitive performance. For instance, Porter and van der Linde (1995a) suggested that properly designed environmental regulations can encourage technological development, promote firms' environmental activities, and enhance environmental performance. Technological development and improvement in resource productivity can increase firms' competitive advantage and enhance their overall economic performance. On the contrary, a second set of surveys argue that there is not enough empirical evidence showing that environmental regulation severely affects economic performance, and economists shouldn't therefore care too much about industrial competitiveness (Roberts 1992, Cropper and Oates 1993, Jaffe *et al.* 1995, Telle and Larsson, 2007, Lee 2008).

The second level of analysis refers the relationship between competitive and environmental performance. Empirical studies have attempted to assess whether a balanced relationship can exist between environmental and economic performance (Russo and Fouts, 1997; Hart and Ahuja, 1996). Some researchers argue that no positive relationship exists between economic and environmental performance (Walley and

[12] An economy that reduces carbon dependency, addresses poverty, generates good quality and decent jobs, maintains and restores our natural ecosystems, and moves towards sustainable consumption (UNEP, 2009).

Whitehead, 1994) or that benefits may occur only under specific conditions (Rugman and Verbeke, 1998).

The third ambit of analysis focuses on the effect of environmental practices on competitive performance. The empirical studies focused on several environmental practices: reporting, environmental management systems, suppliers engagements, etc. The evidence is very mixed on this subject: some studies found a weak or a non statistically significant relation (Clausen *et al.*, 2002), while other studies reached the opposite conclusion (Zhu and Sarkis, 2004; Rennings *et al.* 2006).

In this framework, the main question for this dissertation has been formulated:

> *How can the environmental regulation and practices be effective, or improve the environmental performance of the firms and provide competitive advantages to the targeted firms or adopters?*

Several research questions have been derived from this:

I) Is a stringent environmental regulation able to positively affect the competitive performance of firms?

II) Which are the main differences among the forms of environmental regulation in the relation between environmental regulation, environmental performance and competitiveness?

III) Are the flexible forms of environmental regulation, such as voluntary instruments on environmental management systems, able to influence the environmental and competitive performance?

IV) Which are the effects of environmental practices based on the cooperation between the supply chain actors?

2. Summary and conclusion

Regarding the relationship between environmental regulation and competitiveness *(research questions I* and *II*), I explored how does the environmental policy stringency and the form of environmental regulation affect the competitive performance of firms in the building and construction sector. To assess the link between environmental regulation and competitive performance a dataset collected by means of interviews was used and an empirical model based on a probit regression was tested. A set of equations was defined: the dependent variables are the different measure of competitiveness and the independent variables are the level of stringency and the impact of different forms of environmental regulation. The empirical results show that a more stringent environmental regulation provides a positive impulse for increasing investments in advanced technological equipments and innovative products; moreover, it stimulates the qualitative improvement of human resources in term of technical competence and the realisation of green business opportunities. Furthermore, regarding the form of regulation the study clearly shows that direct regulation has a direct and significant effect on some competitive performance of companies, in particular on firms' innovation capabilities. On the contrary, it emerges that economic instruments negatively affect business performance. Finally, I find that soft instruments are beginning to be effective on competitiveness, but their influence is still not very high, especially on those performance on which they should have the main implications, i.e.: those most connected to the market dynamics. Soft instruments are able to stimulate innovation abilities by the firms and to improve "intangible assets", such as reputation and technical competence, but they are not capable of changing market trends or demand pressure (by orientating them towards more sustainable products). Starting from these considerations I focused the next part of the thesis on a particular instrument such as the environmental management system within the European Union's Eco-Management and Audit Scheme (*reseach question III*).

Environmental Management Systems (EMS) are voluntary schemes designed to help organizations provide good environmental management. Two widely-used schemes are the international standard for environmental systems, ISO/EN 14001, and the EU's Eco-Management and Audit Scheme (EMAS). Although still voluntary, EMAS has legal status within Member States, and goes further than the ISO/EN 14001 by requiring an organization to continually improve environmental performance, to undergo an audit to demonstrate compliance, to provide public information through annual reporting and to ensure the active involvement of employees. However, there is debate over the extent to which an EMS can provide both environmental and competitive improvements. Using information collected from the EU-funded EVER project, I examined whether an EMS, and EMAS in particular, is able to enhance the competitive performance of an organization, as a result of improved environmental performance.

I find that the longer an organization has implemented an EMS, the greater the level of environmental performance. This is mainly achieved by continuous improvement of environmental performance and learning from experience. However, the ability to improve can decline over time through, for example, the increasing cost of abating pollution and difficulties in identifying new opportunities for improvement every year.

Moreover, there is a strong link between incorporating an EMS and being able to successfully plan and achieve environmental targets. If an organization can thoroughly integrate the EMS and include environmental criteria in daily operational plans and activities, it will achieve greater environmental performance. Regarding the competitive performance, innovative capabilities, such as new technologies and organizational solutions which improve environmental performance are linked to a competitive advantage. An organization that invests in finding innovative environmental measures is more capable of developing and managing new technologies.

However, other signs of strong competitiveness, such as market performance (for example, feedback from customers), intangible assets (such as human capital) and resource productivity (operating performance) could not be closely related to a strong environmental performance. Finally, in contrast to other studies, I suggest that the length of EMS registration does not improve competitiveness. Rather, it is the degree to which the EMS is embedded within an organization that provides business results, implying that even newly registered organizations can gain competitive benefits provided the scheme is well implemented and managed.

EMS is both an environmental policy instrument and an environmental practice that an organization can adopt to improve its performance. The relation between environmental practices and performance is the focus of the last section of the thesis (*reseach question*

IV). I analyzed the environmental practices based on the cooperation between the supply chain actors, called green supply chain management. These practices are based on life cycle thinking, on the involvement of the actors of supply chain to identify greener technical solutions for the improvement of product environmental impact.

The analysis investigates which are the determinants of green supply chain management and its effect on environmental and economic performance. Regarding the performance, the study confirms the cooperation with suppliers on environmental issue produce environmental improvement. The most common environmental impacts of industrial companies can (and are) ameliorated by making suppliers and customers actively participate in the programs and actions that a company sets to this aim. From the achieved results, we can therefore deduct that the more a company is able to involve its business partners in the development of co-operative environmental plans, the more it is able to achieve the expected results and to improve its performance. On the contrary the relation between environmental practices and economic performance is not strongly supported by the evidence of my study. In this case, the findings are much less positive than expected: not only GSCM is a rather "expensive" approach to be implemented by a company, but it also seems incapable of yielding profits, at least in the short-medium run.

3. Discussion and recommendations

The analysis of the relationship between environment and competitiveness can be investigated by different perspectives and a high number of external variables can exert their influence. Before to provide some final considerations, two issue need more discussions: *data availability and quality* and the *scope and the limitations of this research*.

First, analyzing the firms' performance, both environmental and competitive, and the regulatory pressure, is known to suffer from measurement problems as well as lack of consistently collected and reliable data. For this reason, I used perceived measures collected by interviews with firms' managers. Even if this approach is widely used in literature (see the main reference cited in the previous chapters), all the actions were made to avoid bias risks, some results are consistent with quantitative studies, a further development of this analysis refers to the use of quantitative data. The second issue refers to the complexity of the topic. As I mentioned above, the analysis of the relationship between environment and competitiveness at the firm level can be investigated by different perspectives: in my dissertation I focused on specific ambits of analysis such as the building & construction sector in the chapter 2, a very diffused soft instrument in the chapter 3 and an important environmental practice in the chapter 4. These choices have to be taken into account in the analysis of the results and recommendations.

These limitations did not prevent this work from providing new and useful contributions on how the relationship between environment and competitiveness can be enforced at the firm level. In particular, with respect to *policy makers* and *managers*, some constructive recommendations can be made:

- *Importance and effectiveness of direct regulation:* despite the outcome of many studies identified in literature, the study clearly shows that direct regulation has a direct and significant effect on some competitive performance of companies. More precisely, direct regulation has an effect on firms' innovation capabilities. Moreover, the level of stringency and the intensity of the monitoring and control activities are a powerful incentive to improve the environmental and competitive performance. Some new forms of direct regulation, focusing more on technological standards than on emission limits, seem to be particularly effective on competitive performances (e.g. the IPPC Directive approach). This means that the first policy recommendation emerging from the study should be that of maintaining direct regulation as one of the most effective environmental policies, keeping in mind that if properly conceived, it can produce positive effects also on competitiveness.

- *Economic instruments should be accompanied by compensation measures.* One of the main outcome of the study is a confirmation to a traditional viewpoint on the effects of this kind of policy measure: they do negatively affect business performance. This assumption is strongly discussed by a large part of the literature (i.e.: the scholars referring to the Porter's theory), but it seems to be supported (even if weakly) by thesis's results. Therefore, a second policy recommendation is that of using economic instruments (especially pigouvian taxes) taking into account that they can hamper firms' competitive performance. Therefore, when used, these policy instruments should be applied together with compensation measures, such as subsidies for "sensitive" companies (e.g.: SMEs) or for the best performing companies under the environmental point of view (subsidizing the "champions" could lead to an emulative effect).

- *Soft instruments should be strengthened by way of a higher institutional and policy support.* The findings of the study clearly show that soft instruments are beginning to be effective on competitiveness, but their influence is still not very high, especially on those performance on which they should have the main implications, i.e.: those most connected to the market dynamics. Soft instruments are able to stimulate innovation abilities by the firms and to improve "intangible assets", such as reputation and image, but they are not capable of changing market trends or demand pressure (by orientating them towards more sustainable products). "Soft instruments" are conceived to have an impact on competition, therefore the findings of our study are rather disappointing for policy makers. The failure of "soft instruments" is due to a lack of awareness and availability to behave in a more sustainable way in market choices by intermediate customers and final consumers, more than to drawbacks or misuse in their application. Therefore, I suggest to strengthen the use and diffusion of "soft instruments" also by reinforcing the demand-side i.e. by creating a "demand capacity" in the intermediate and final markets for more sustainable products and services (e.g.: by way of information and sensitization public campaigns, enacting GPP-supporting policies and incentives, ecc.).

- *The adoption of formal tools does not guarantee the improvement of performance.* The mere adoption of formal environmental initiatives such as the environmental management system does not provide immediate benefit both on environmental and competitive performance. Rather, it is the degree to which the EMS is embedded within an organization that provides business results, implying that an organization can gain competitive benefits if the tool is well implemented and managed. These considerations can be also extended to other formal tools, such as environmental accountability, life cycle analyses, Corporate social Responsibility tools, to which practitioners and policy makers associate notable benefits for adopters.

- *Market-initiative are necessary to increase the value of environmental initiatives towards customers.* The internal benefits such as participation and motivation of personnel, competence of technicians do not represent a considerable stimulus for a firm to adopt an environmental practice, even if they can create value added in a medium term. A final and crucial indication stemming from my work is the need to work on the "market-response" for environmental initiatives (like green supply chain management), in such a way to foster the profitability of these strategies and to stimulate companies to increasingly adopt them.

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